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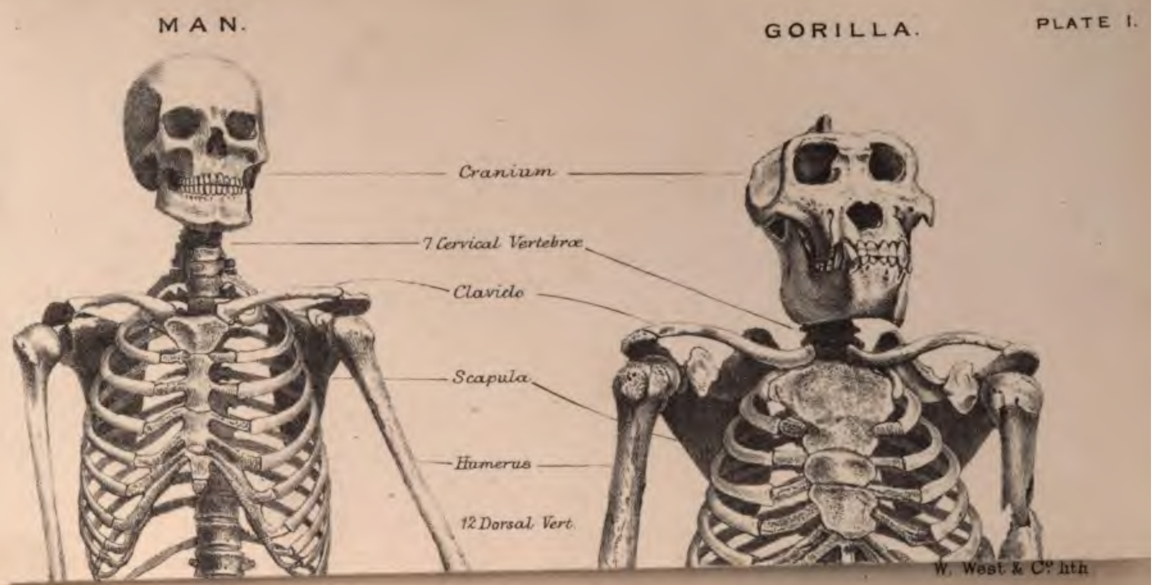
STUDENT'S GUIDE

TO

HUMAN OSTEOLOGY

PLATE I.


MAN.
GORILLA.
Cranium
7 Cervical Vertebræ
Clavicle
Scapula
Humerus
12 Dorsal Vert.
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STUDENT'S GUIDE

TO

HUMAN OSTEOLOGY

BY

illiam arwick
W. W. WAGSTAFFE, B.A., F.R.C.S.

ASSISTANT-SURGEON TO, AND LECTURER ON ANATOMY
AT ST. THOMAS'S HOSPITAL.

LONDON
J. & A. CHURCHILL, NEW BURLINGTON STREET
1875

TO

F. LE GROS CLARK, F.R.S., &c.

PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS, 1874-5,
CONSULTING SURGEON TO ST. THOMAS'S HOSPITAL,
ETC. ETC. ETC.

This Work is Dedicated,

AS A TOKEN OF RESPECT FOR HIS GREAT PERSONAL WORTH,

AND FOR HIS ATTAINMENTS

AS A SURGEON AND AN ANATOMIST,

AND IN AFFECTIONATE REGARD FOR THE MANY ACTS

OF KINDNESS SHOWN TO

THE AUTHOR,

AS PUPIL, COLLEAGUE, AND FRIEND.

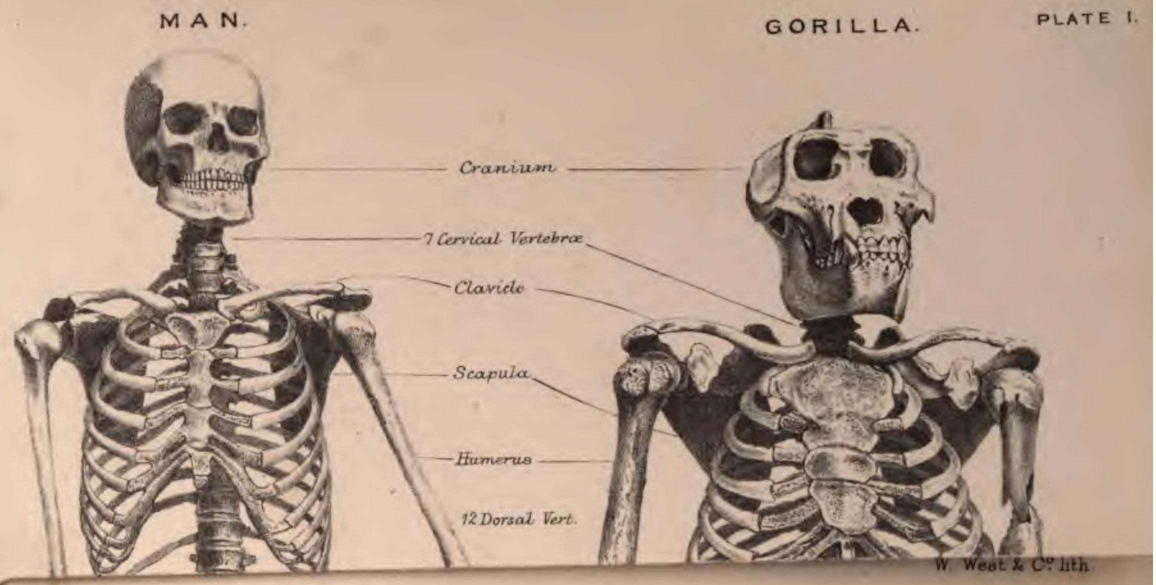
PREFACE.

The main object in this work has been to describe the bones of the human skeleton with accuracy but without wordiness, and the secondary object to interest the student in the mechanical wonders of his framework. He must however remember, that neither written descriptions nor plates will suffice to teach osteology. The bone that is under consideration must be always before him at the time, otherwise his study will be in vain.

In the parts of the work which contain the description of the bones, I have here and there often followed a somewhat different plan from that hitherto employed in text-books on this subject, and where this has been done I have generally called attention to the fact. The accounts of the mechanical structure of the bones are chiefly the result of observations which I have rather recently made, and published in 1875, in the "St. Thomas's Hospital Reports."

In the interest of the student I have taken the simplest bones first for examination, beginning with the extremities before taking the more difficult bones of the skull, and I have endeavoured to make the text more easy of reference by putting in strongly

PLATE I.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NOTE

On the Skulls of Different Races of Mankind, page 268.

THE typical crania of the native Americans and of the Malay races differ in certain important features from the Caucasian, the Mongolian, and the Ethiopian, and I am indebted to the kindness of Mr. Westley for the following observations upon this subject:—

AMERICAN RACES.

1. *Esquimaux.*—It is impossible to regard these as of the same race as the red men who inhabit the greater part of North and South America. Indeed I believe that from the time of Blumenbach, who regarded the Esquimaux as of the same race as the Mongolians, they have usually been considered as quite distinct from the rest of the American races.

The skulls of the Esquimaux are, notwithstanding the small stature of the race, of an average size. Their prevailing form is dolichocephalic—a comparison of 37 skulls showing a breadth of form of from 69 to 75 (length being assumed as 100). In internal capacity Esquimaux skulls are not deficient —22 skulls having an average capacity in cubic inches of 90·6 (32 English skulls giving an average of 90·9). The skulls of Esquimaux are otherwise

characterized by great breadth at the base, *flatness and breadth of face*, very widespreading zygomata, and narrow, somewhat depressed nasal bones. They also frequently present a remarkably pyramidal form above, and have often a ridge in the line of the frontal suture. They are only slightly prognathous.

2. *Americans proper, or Red Men.*—Over so vast a range as is presented by the continents of North and South America it must of course be expected that the races of men by which it is peopled should show great diversities of characteristics, and we consequently find that it is a matter of great difficulty to frame a description of American crania so general as to include the whole of these races. At the same time I believe that the whole continent is inhabited substantially by one race (with the exception of course of the Esquimaux). The great prevalence, moreover, of artificial distortion of the skull amongst these races, renders measurement less easy to be obtained and also less to be depended on.

There has been great difference of opinion as to whether the American skull is dolichocephalic or brachycephalic. I think that upon the whole the balance of evidence is decidedly in favour of the latter form, as that of the *undeformed* American skull. With regard to capacity a comparison of 13 skulls gave average of from 88 to 94 cubic inches. The other characteristics appear to be a narrow and retreating forehead, moderately prominent brow ridges, a narrow, high, and aquiline nose, widespreading

and prominent malar bones, and a slight degree of prognathism. Wormian bones in the course of the sutures are exceedingly common, probably in consequence of the pressure to which the skulls have been subjected in the process of artificial distortion.

Malay Races.

The name "Malay Race," which was first applied by Blumenbach, and under which he classed almost all the Oceanic races—including those of the islands of the Pacific Ocean—is now generally regarded as a somewhat fanciful division. It is at least certain that many distinct races were classed by Blumenbach under the name Malay. He describes them as "tawny-coloured, hair black, soft, curly and thick, head moderately narrowed, forehead slightly swelling, nose full, rather wide and thick at the end, mouth large, jaw prominent." This description appears to agree very well with the characters of the Malayans proper (inhabitants of the Malay peninsula), but certainly not with those of many of the islands which Blumenbach considered peopled by Malayans. To me it appears, though I have not access to sufficient data to speak very positively about it, that the inhabitants of the Malay peninsula are somewhat allied with the Chinese in their characteristics, so far as their skulls are concerned. Borneo and the adjacent islands are peopled by Dyak races, more or less like the Malays, and the island of New Guinea has inhabitants closely resembling those of Australia.

In the Andaman and a few other islands occur the *Negritos,* a race almost in every respect like the Negro, except that the hair appears not quite so woolly. The various groups of islands in the Pacific, as well as New Zealand, appear to be peopled with a more or less allied race somewhat resembling the Malays, and totally distinct from the Negrito and the Papuan, and Australian. The subject of the races of the islands of the Southern hemisphere is a very intricate one.

CONTENTS.

PAGE

LITHOGRAPHIC PLATES.

Note.—The plain red lines indicate the origin, and the dotted red lines the insertion of muscles. The names of the muscles are marked in red on the sides. The bones are taken from the right side of the skeleton with one exception, in Plate XXIII.

LIST OF WOODCUTS.

HUMAN OSTEOLOGY.

ERRATA.

Page 28, line 5 from the bottom, *after* "backward
"inwards."

" 36 " 5 from the top, *for* "small" *read* "sho

" 44 " 10 from the bottom, *for* "concave'
"convex."

" 56 " 7 from the top, *for* "extensor" *read* "f

" 114 " 6 from the bottom, *for* "outer" *read* "i

" 172 }
" 178 } " 1 from the top, *for* "XIV." *read* "X."

" 195 " 1 from the top, *for* "XI." *read* "XIV."

and the lungs, they accordingly vary greatly in their construction, and a knowledge of their natural shape and character is essential in order to be able to distinguish any defect in them arising from disease, injury, or deformity. Without this knowledge of Osteology no one can become a skilled anatomist or

HUMAN OSTEOLOGY.

INTRODUCTION.

Human Osteology is the Study of the Human Skeleton—the framework upon which our soft parts are supported. Like Anatomy, or the result of Dissections, it is made up of facts, which have been ascertained by careful observations, and are all capable of proof by an ordinary observer. Upon such a subject a text-book will necessarily be a mere record of disjointed facts, unless they be relieved by an attempt to trace them to their causes or to their results. Many indeed look upon Osteology as the type of a hard and uninteresting study, but this ought not to be. It may be hard, but uninteresting it should not be, for it is so absolutely essential, and so capable of proof. The absolute necessity of it to the student of Anatomy or Surgery is acknowledged, for as bones are either levers to be acted upon by the muscles, or form protecting cases to delicate structures lying within, like the brain, the heart, and the lungs, they accordingly vary greatly in their construction, and a knowledge of their natural shape and character is essential in order to be able to distinguish any defect in them arising from disease, injury, or deformity. Without this knowledge of Osteology no one can become a skilled anatomist or

surgeon, and it has been truly said that Osteology is the foundation upon which the superstructure of medical and surgical knowledge must be raised. Nor is the necessity for a thorough acquaintance with the subject confined to the medical student only. The artist or the sculptor, who aims at delineating the proportions and beauty of the human figure, must seek in Osteology the only reliable basis of accuracy and truthfulness.

The knowledge of the human skeleton is so important that it is enforced upon the student at the very threshold of his professional work: constant recourse to the skeleton will have to be made during the whole course of his dissections, while not less frequently, perhaps, will the surgeon find the necessity of referring to it in cases of dislocation and fracture, disease and deformity—surely, then, the greatest elements of interest that any study can offer are present. It is useful and necessary as a means to an end—that of obtaining further knowledge.

Doubtless there is much in the study of Bones that is merely descriptive, and being descriptive of a large array of abstract, unconnected facts which *must* be known by heart and made available as pegs to hang inferences upon, will necessarily be difficult to remember, for these very facts often appear to be as causeless as they are disconnected. But if we look more carefully into their causes and their results, if we regard their mechanical bearings especially, as well as their bearings upon Surgery, upon the origin of deformities, and the nature of injuries, the study of Osteology becomes deeply interesting. We see in the form and structure of an apparently unmeaning mass of bone, provisions for the working of a power of whose nature we know little, but which employs an endless variety of means,

and among these, mechanical forces and mechanical contrivances of infinite beauty and simplicity, which far surpass our most complicated inventions in their effects, and in principle often anticipate the novel discoveries of our acutest mechanicians.

THE SKELETON is the bony framework upon which the soft structures of the body are placed. It is composed of numerous pieces which act as the levers for motion, or are arranged with a view to the protection of delicate internal organs, or act as points of support for the limbs. It consists of a central column, three great bony cavities, and four extremities or limbs. The cavities are connected one with each end of the central column, and the third with its centre. The limbs are attached in pairs to the walls of the central and of the lower cavity.

The column is called the *spine.*

The upper cavity constitutes the *skull,* the middle the *thorax,* the lower the *pelvis.*

The limbs are respectively *arms* and *legs.*

Number of Bones.—The number of bones in the human skeleton depends upon what are considered separate bones. There are several small bony masses —*sesamoid,* pea-like—found in the tendons of muscles; there are the *teeth,* not of the same character as bones, but sometimes included with them; there are several isolated pieces of bone commonly found in the lines of union of the skull bones (*Wormian bones*), but they are not constant in number.

Excluding these, there are 210, including the lenticular,* which is the smallest bone in the body, the sphenoidal turbinated bones, which are nearly the

* This bone is sometimes looked upon as a tubercle of an adjoining bone—the incus.

thinnest, but taking the sphenoid and occipital as one—the spheno-occipital.

Of these 210, 32 belong to the skull (including the Hyoid).

24	,,	spine.
26	,,	chest.*
4	,,	pelvis.†
64	,,	two upper limbs.
60	,,	two lower ,,

Varieties of Bones.—In commencing the study of the bones it is necessary to explain the meaning of certain terms frequently used in describing them.

Bones are called *long*, *short*, *flat*, or *mixed*, according to their shape.

The *long* bones are the levers, a good example of which is seen in the femur or the humerus.

The *short* or cuboid bones are found where many joints are required, or where force is to be distributed over oblique surfaces. An example of the former is to be found in the vertebræ, of the latter in the wrist and ankle.

The *flat* bones usually occur in the construction of cavities, as may be seen in the cranium and pelvis.

The *mixed* bones partake of the characters of both long and flat bones, as in the sternum or breast-bone, the ribs and the lower jaw.

Structure.—There are certain points in the structure of bones with which it is necessary to be acquainted before examining the bones separately. Each bone is covered by a fibrous investment called the *periosteum*, which is full of vessels carrying blood for the supply of

* Excluding the vertebræ.

† Including the Sacrum and Coccyx, which are coalesced vertebræ.

the bone. This periosteum dips with the vessels into every little opening, so as to line the hollows and spaces which are found in the interior of the bone, but when it has reached the interior it is called *endosteum*, or internal periosteum. If we look at the larger ends of the femur or the tibia, we shall see numbers of small holes through which the periosteum and vessels have passed.

Notice also another point with respect to the periosteum. When the finger touches it it feels smooth and moist, when it is struck with a probe it sounds dull. Remove this periosteum, and now the surface is felt to be hard and rough, and when struck it sounds almost metallic. This difference enables the surgeon to distinguish between a bone that is healthily covered, and one that is denuded or dead, at the bottom of a wound or hole.

Under the periosteum, and perforated in numerous places by it, is the solid bone, which varies in density in different parts. Near the outside it is always compact, and there is called "*compact tissue*;" near the centre it becomes spongy or porous, and here it is called "*cancellous tissue*."

Notice now that where strength is required (as in the *shafts* of long bones), the tissue is compact; but where bones are expanded to form large surfaces for support (as *heads of femur, tibia, humerus, &c.*), or for attachment of muscles (*olecranon, trochanters of femur, and tuberosities of humerus*); or where lightness is required with strength, as in the short bones (*tarsus, carpus, vertebræ*), the tissue is cancellous.

In the bones of the skull, where great strength is required to protect the brain from blows and other injuries, we find that in addition to the curved form

and the dovetailing of the bones along their lines of junction, the substance of the bones is made up of a compact layer outside, called sometimes the *external table*, then a small quantity of cancellous tissue here called *diploë*; then another layer of extremely dense tissue, so dense and brittle that it has a tendency to splinter like glass, and this is called the *inner, or vitreous table.*

Numerous canals are found in the compact tissue, and are called *Haversian canals.* They are occupied by vessels and nerves, and the spaces which are found in the cancellous tissue in like manner have numerous vessels and nerves and lymphatics. But the canals and spaces are occupied also by a quantity of fat, and by a large amount of cell growth of a rather peculiar character. The soft contents of these spaces and of the hollow shafts of long bones constitute what is commonly known as the marrow of the bone.

Bones differ in their character a good deal according to age, the use to which they have been put, and the existence of disease. In early life they are not fully ossified; in old age they lose much of their solids, and a much larger quantity of the fatty constituents is present; roughly speaking, there is more marrow.

Where the bones have not been used they do not possess the same amount of compact tissue, but all parts have a tendency to become porous and show a cancellous arrangement. Hospital museums frequently contain specimens of the thigh-bones of patients who had been in bed for years before they died, and in such it may be noticed how porous the bone is, and how much greater chance there would be of a fracture occurring in them than in those of healthy texture.

On the other hand, in extremely muscular, active persons the ordinary ridges and prominences become much more marked, and consequently also in men rather than in women. A male bone is therefore usually rougher than a female bone.

Mechanics of Bones.—It will be noticed in considering the mechanism of each bone, that there are certain principles or features in bones generally which are of great importance. These are strength, elasticity, lightness; and they are provided for in various ways. Where great strength is required, there great compactness or massiveness is found; where great elasticity is necessary, the shape of the bone is modified, and we find curves and spirals, sometimes further increased by the arrangement of curves in the bone fibres of the cancellous tissue; where lightness is especially requisite the bone is porous, and then it is always strengthened by the mechanical arrangement of its fibres.

The ends of the long bones are in nearly all cases enlarged, and the object is either to provide attachment for muscles so as to bring the acting point of the power as near as possible to the fulcrum, or else for the purpose of giving steadier play to the joint; and here it is that we can trace a curious and wonderful adaptation of mechanics certainly surpassing in its ingenuity, simpleness, and efficacy any of the most wonderful products of human skill. Strength, lightness, and elasticity are here combined in perfection, for the seemingly structureless mass of spongy bone is so constructed as to withstand the constant shocks from various directions to which joints are liable in the almost endless movements of the body.

The spicules and fibres and plates composing the cancellous tissue are always arranged in definite curved lines; and these curved lines are always related to the mechanical requirements of the part. Examine a section of the head and neck of the thigh-bone (Fig. 30), or the lower end of the same bone (Fig. 32), or the two extremities of the shin-bone (Figs. 34–37), or a vertebra (Figs. 51–54). You will find in all of them that the rods of bone in the cancellous tissue do not at all correspond with the outline of the bone, but they form curves which are best adapted to withstand violence or pressure in the directions it is usually applied.

Some notice of this mechanical arrangement has been customary in referring to the neck of the thigh-bone and the head of the tibia, and resemblances have been shown, although rough and imperfect, between the architectural arrangement in these parts, and simple mechanical structures like the bracket and gothic arch; but it has not been hitherto generally noticed* that in *all cancellous tissues* there is a definite mechanical arrangement, insuring the greatest strength and elasticity along the lines of greatest pressure.

It is an interesting question to determine how far this mechanical arrangement is the result of conditions present in the living skeleton—how far, in fact, the architecture is the result of, rather than a provision for, pressure in certain directions. Doubtless this architecture may, like any other intimate structure, be hereditary; and just as the features of a child resemble those of his parent, so the construction of

* Professor Humphry's observations on this subject in his "Human Skeleton," published 1858, have been overlooked by all writers, Continental and English.

the bones of the child may copy that of his parents; but inasmuch as physical forces, such as attraction, gravitation, electricity, heat, and chemical action, are necessarily acting upon the embryo in its formation, it seems more than probable that during the deposit of bony matter in the cartilaginous temporary structure its determination in certain lines is influenced by pressure and other known physical forces.

The lines seen in various sections differ in clearness of delineation according to the age and character of the bone, and also according to the direction of the section. With regard to the former points much remains to be yet investigated, and with regard to the latter it must be noticed that the lines indicate the existence of plates rather than columns, though it is more convenient to refer to them under the latter term since that is their appearance on section. In many specimens I possess the plates are perfectly distinct, but when these are cut obliquely they are not so easily traced.

These observations will be of interest not only to students of anatomy, but to those engaged in mechanics generally. No doubt we have in the human skeleton many and varying directions in which force is applied, and therefore many are the requirements to be met in the construction of bones, but it seems to me that a study of the architecture of these parts suggests an improvement in mechanical constructions generally, even where the requirements are fewer than in a complicated human lever, and that curved lines might with great advantage be made use of in preference to straight ones, as by their elasticity they insure far greater stability.

A practical bearing of this question occurs in the

direction of fracture from indirect violence both in the shaft and towards the ends of long bones. The solid substance of the shaft is constructed upon the same principle as the better-defined cancellous tissue, for in bones which have become atrophied from any cause a curvilinear fibrous arrangement is traceable in the shafts, and when bones are decalcified they can be torn along the same lines more readily than in other directions. Fractures of shafts from indirect violence are almost always oblique, and in looking over a large number of specimens I find that the obliquity of the fracture coincides with the obliquity of the curves seen in atrophied bones.

In the new bone which is deposited about old united fractures there is also a definite arrangement of the bony fibres which compose it, and these fibres are placed in the direction of the greatest pressure.

In the *curves* and *ridges* and *obliquities* of the bones there are certain advantages not usually noticed. All the long bones are curved in their length and on their surfaces, all the short bones have curved outlines, and by this contrivance the shock of falls and blows is materially lessened. The durability of carriage wheels is said to be greatly increased by a slight curvature in their spokes, and in the human skeleton there seems no doubt that both the internal organs and brain are preserved from injury, and the bones are themselves less liable to fracture, owing to the numerous curves which break the violence of concussions.

Ridges are seen on all long bones, and the surfaces are grooved, so as to give an impression of the bones being twisted, for the grooves and ridges are always spiral or curved. This arrangement still further adds to the elasticity of bones.

Bones are also *obliquely* placed. Their shafts run obliquely sometimes, as in the femur, or the surfaces for contact with other bones are oblique, as in the ankle and wrist, and the result of such arrangement is exactly that seen in the inclined plane. Force is distributed, and direct pressure lessened, so that injury is less likely to happen to the bones.

Experiments have been made to determine the actual and relative strength of bone, and the following table, drawn up by Professor Robinson, indicates the relative amount of pressure which a square inch of certain substances will bear, taking that of fine freestone as 1:—

Freestone	1
Lead	6·5
Elm and ash	8·5
Box, yew, and oak	11·0
Bone	22·0

Bone therefore will, according to Professor Robinson's results, support twice the pressure that oak is capable of, and an inch square is computed to bear 5000lb. weight. This refers to solid or compact bone.

In some experiments which were undertaken for me by Mr. W. T. Goolden to test the resisting power of bone the following results were obtained:—

A piece of the middle of the shaft of the femur, rather dry, but covered with periosteum, an inch and a half in length, and one and a quarter in breadth, was submitted to hydraulic pressure. At a pressure of one ton and three hundredweight it was split to the extent of one-third of an inch along its outer surface. With two tons and three hundredweight it broke into three pieces.

Cancellous tissue is less strong, but a cubic inch

of this taken from the lower end of the femur "sustained four hundredweight without sensible alteration. With six hundredweight its height was reduced to half an inch" (Ward). This experiment was performed with dry bone, and therefore was unsatisfactory, as much of the tenacity of the bone was thereby lost.

For further remarks on this subject, see Mechanism of the Skeleton.

Formation of Bone.—It will be necessary to offer some explanation with regard to the formation of bone; as we shall have to refer to what are termed centres of ossification, and to epiphyses.

Early in the life of the embryo, when out of an almost shapeless mass of cells of which it is composed we begin to distinguish one part of the body that-is-to-be from another, indications are to be seen of cartilage, or membrane, where bone will by-and-by be found. After a short time, small points of earthy deposit can be discovered at definite spots in the cartilage or membrane, and from these points bone formation proceeds, by spreading in particular directions. But each bone does not ossify from one single centre. The majority have more than one. In the long bones there is always one for the shaft, and generally one or more for each extremity, and usually one for each special prominence on the bone. It is important to know what these centres are, and when they unite, for a blow or a violent pull may cause the separation of them, and it is necessary to be aware of this in order to avoid an error in the diagnosis of such cases. It may be taken as a rule that the shaft of a long bone has united with its epiphyses usually by the age of twenty or twenty-five;

and as increase in the length of a bone occurs almost entirely by new growth at the ends of the shaft, when the epiphyses join the shaft the latter ceases to elongate. It will be seen, therefore, that the junction of the epiphyses with the shafts coincides with, and is the cause of the cessation in growth of an individual.

Terms.—In anatomy many special terms are used to designate certain appearances or structures—terms curiously applied in many instances, very often of doubtful origin, and used with little regard to consistency.

Some of the commoner descriptive terms may be here referred to, but the rest are to be found in the index.

The term *cotyloid* (κοτύλη, a cup) or cuplike, is applied to a cavity which is hemispherical.

glenoid (γλήνη, the pupil of the eye) to a cavity which is less cupped.

trochlear (τροχίλια, a wheel, by turning which water was drawn up, a pulley; τρεχω, I turn) to a convex or concave surface, which is grooved, pulley-like.

facet (facette) to a surface which is flat.

socket or *alveolus* to a deep conical hollow.

sinus (a hollow) to a chamber whose outlet is comparatively small.

fossa (a ditch) to a smooth depression, or a chamber with large aperture.

mastoid (μάστος, a nipple) to a process which is nipple-like.

odontoid (ὄδους, a tooth) to a process which is tooth-like.

coracoid (κόραξ, a crow) to a process which is curved like a crow's beak.

styloid (στῦλος, a column, an ancient pen) to a process which is pointed and long.

serrated (serra, a saw) to a process which is saw-like.

vaginal (vagina, a sheath) to a process with two flaps like the leaves of a book.

pterygoid (πτέρυξ, a wing) to a process which is wing-like.

condyloid (κόνδυλος, a knuckle), knuckle-like.

trochanter (τροχαντῆρ ; τρεχω, I turn), a large process which rotates.

scaphoid (σκάφη, anything scooped out; a boat), hollowed out, boat-like.

coronoid (κορώνη, beak), beak-like or crown-like.

Simple terms like *prominences*, *tuberosities*, *tubercles*, *lines*, *ridges*, *crests*, *notches*, *holes*, *grooves*, *canals*, *clefts*, and *fissures*, and the like, require no explanation.

In the use of the terms *interior* and *internal*, it is advisable to make a clear distinction—to apply internal and external with regard to the middle line of the body; interior and exterior with regard to the middle line of the bone. At the upper end of the tibia, for instance, you find externally a facet for the fibula, internally a groove for the tendon of a muscle; in the interior you find cancellous tissue arranged peculiarly so as to give the greatest strength to the bone.

An *articulation* is a joint.

The *direction* of a surface is that in which it looks, and is therefore indicated by a line drawn perpendicular to it.

Inclination by a line drawn parallel to it.

Homology means the correspondence of parts in structure, and not in function: thus the upper limbs of man are *homologous* with the forelegs of quadrupeds, and the wings of birds.

CLAVICLE.—Plate III.

Synonyms: *E.* Collar-bone. *G.* Schlüsselbein. *Fr.* Clavicule. *L.* Clavicula, jugulum, ligula, os furcale.

Situation.—The clavicle is placed horizontally above the first rib, being attached by one end to the sternum and by the other to the acromion process of the scapula. The clavicle helps to give squareness to the shoulders. It is prone to injury from direct violence, but is more liable to be fractured by blows upon the shoulder, as in falling, and is the bone more frequently broken than any other in the body.

Shape.—In general outline it is like the italic *f*, and takes its name from a resemblance to an ancient key (clavis). It is thick at its inner or *sternal* end, flattened from above downwards at its *acromial* end, prismatic in the middle of its *shaft*. Its upper surface is generally convex and smooth, its lower surface is grooved and at the extremities rough. It is doubly curved, convex forwards in its sternal two thirds, concave forwards in its acromial third. These curves can be felt under the skin. Its roughness varies with the muscularity of the individual, and is therefore usually rougher in males than in females.

Parts.—**Acromial end** flattened from above downwards and rather more hollow below than above. It has two surfaces and three borders. *Upper surface* flattened, slightly rough, often perforated, covered by an aponeurosis or fibrous membrane, extending between two muscles (*trapezius* and *deltoid*). *Lower surface* rough, often rather concave, presenting a tubercle and ridge. *Tubercle* (**Conoid Tubercle**) found near

the posterior margin, where the acromial end joins the shaft. It lies in the articulated skeleton, over the coracoid process of the scapula, and gives attachment to a ligament (the *conoid*).

Ridge (**Trapezoid**) running obliquely across from the tubercle to the anterior and outer extremity. It gives attachment to a ligament (*Trapezoid ligament*), which also connects the bone to the coracoid process of the scapula. *Anterior border* rather concave; *posterior border* convex; *outer border* rounded but showing a small flat *articular facet* for the acromion process of the scapula.

Shaft or **body** extending from the conoid tubercle to about one inch from the sternal extremity, convex forwards and presenting two surfaces and two borders. *Upper surface* smooth, convex in the middle, flattened towards each end. This surface looks rather forwards. The inner half is marked off anteriorly from the outer, and here often shows a flat surface for the attachment of a muscle (*pectoralis major*), then comes a smooth surface for a fibrous septum between the last named muscle and another (*the Deltoid*), which is attached to the front edge of the outer third of the bone. *Under surface* grooved, especially towards its outer end (**subclavian groove**), in which a muscle is inserted (*subclavius*). There is usually a small canal (for *nutrient artery*) at the outer end of this groove. The inner part of this surface is smooth and sometimes visibly grooved from before backwards (for the *subclavian artery*). *Anterior border* sharp, convex anteriorly from one end to the other. It gives attachment to the *costo-coracoid membrane*, and separates the upper from the lower surface. *Posterior border* rounded, smooth,

convex from above downwards, but concave from one end to the other. To its inner third is attached the *sterno-mastoid Muscle.*

Sternal end, pyramidal with its base free. *Upper surface* rounded and rough for the attachment of the *sterno-mastoid M.; lower surface* continuous with the under surface of the shaft, but facing more anteriorly. It gives attachment to the *pectoralis major M.* The articular surface of the base is prolonged into this surface. *Posterior surface* continuous with posterior border of the shaft. Along the edge separating the posterior from the lower surface and encroaching on the lower surface is a roughness (**rhomboid impression**) for the *Rhomboid* or *costo-clavicular ligament. Base* triangular with rounded angles, its lower and more prominent angle pointing downwards and backwards. The base is rough above for the attachment of the peculiar fibro-cartilage of the sterno-clavicular articulation, smooth below for articulation with sternum. This articular facet is prolonged on the under surface of the sternal end. It is concave from before backwards, and convex from above downwards.

Articulations.—With sternum at the inner end, with scapula at the acromial end. The first of these small joints is the only means by which the bones of the upper limb are directly connected with those of the trunk.

Development.—From a single point for all except the extreme sternal end where a thin lamina is separately developed (eighteen to twenty years). It is the earliest bone to show signs of ossification: this is said to commence in the sixth week of the life of the embryo, before the appearance of cartilage

in it, and afterwards it goes on in cartilage as well as in fibrous substance. Béclard gives the 30th day for both the clavicle and lower jaw; but as ossification proceeds much faster in the clavicle, it is found much more advanced than the lower jaw by the sixth week.

Mechanism.—The clavicle being curved like a letter *ʃ* is provided with considerable elasticity and strength, much more so than at first sight appears, and being placed in a position where it is so much exposed to violence such a provision commands our admiration. If a clavicle be placed perpendicularly to a wall and struck sharply on its end, it will spring off from the wall to a distance of two feet. If placed upon a stone floor in such a position that it rests like an arch upon its two extremities, and it then be struck sharply it will spring upwards to about the height of a foot. It is, however, in its length that it is exposed to injury generally, as in falls upon the shoulder, and the elasticity which it possesses protects it from fracture, but fracture may and frequently does occur. In fact, the clavicle is the bone most often broken in the body, the fracture usually occurring on the outer side of the middle where the bone is thinnest. This is near the nutrient foramen, and the curves of the bone join here.

If a section be made of a clavicle it will be seen that at each end where it is porous the fibres composing the cancellous tissue are arranged in crossing curves which, however, are not usually very distinct. At the sternal end the fibres radiate in curved lines from the articular surface, a few being placed parallel with the surface. In the acromial portion they are arranged as a series of crossing lines.

Points of importance:—

1. Double curve of the bone.

2. Difference of the ends, the sternal being thick and clubbed, the acromial flattened.

3. Subclavian groove on under surface.

4. Conoid tubercle and trapezoid ridge beneath acromial portion.

5. Earliest bone to ossify.

6. Liability to simple but not to compound fracture.

7. Peculiar articulation at sternal end.

8. Sole means of union of the upper extremity to the trunk.

Mode of determining right from left.—Hold the bone as if in your own body, with the pyramidal thick end inwards, the grooved surface downwards, and the convexity of the inner half pointing forwards: the acromial or flat end points towards the outer side, *i.e.*, to the side to which the bone belongs.

SCAPULA.—Plate II.

Synonyms: *E.* Shoulder-blade. *G.* Schulterblatt n. *Fr.* omoplate. *L.* Scapulum, Scapula, omoplata (ὦμος, shoulder; πλατὺς, broad).

Situation.—The scapula is placed on the back and outer wall of the thorax, covering the ribs from the first to the seventh, and has the humerus suspended from it, while one point of it is connected with the clavicle.

Shape.—It is a flat bone with certain ridges and prominences. In general outline it is triangular with a strong triangular spine running obliquely across its posterior surface and projecting by a well-marked process (acromion process) over the outer angle of the bone. The spine divides the posterior surface into two hollows or fossæ. The front surface or venter is hollow. One of the angles of the bone, the outer, is more massive and shows an oval articular surface (the glenoid cavity), separated from the rest of the bone by a constricted neck from which springs a hooked process (the coracoid process).

Parts.—Two surfaces, three borders, three angles, and two processes.

Anterior surface or **Venter** is concave and the greater part of it forms the **Subscapular fossa.** This fossa does not occupy the whole of the Venter, for each angle is marked off from it. That towards the glenoid cavity is smooth, and continued into the neck of the bone, and over this part the *subscapularis* muscle is free and often separated by a bursa. Towards the lower angle there is an oblique line which separates the fossa from a flat, triangular

surface (for the *serratus magnus*). Towards the upper angle a similar line separates it from a flat surface (also for the *serratus magnus*); and towards the vertebral or inner border is a narrow flat surface for the same muscle. The subscapular fossa is traversed by ridges from which the subscapular muscle rises.

Posterior surface or **Dorsum,** convex, but crossed obliquely by a projecting spine, so that two **fossæ** are produced of which the lower or infra-spinous is the larger. **Supra-spinous fossa** is above the spine; becomes narrow but deeper towards the neck; it is occupied by a muscle (*supra-spinatus*). **Infra-spinous fossa,** shallow but large, is formed by part of the dorsum below the spine. Limited below by an oblique line (sometimes called the oblique line of the scapula) which marks off a distinct flat surface (for the *teres major M.*), and limited towards the thick axillary border by another oblique line extending from the glenoid cavity to that just referred to. This is often indistinct, but when present, indicates the limit of attachment of the *teres minor M.* Notice that each of the three fossæ (subscapular, supra-spinous, and infra-spinous) is deepest opposite the glenoid cavity.

Spine strong, triangular, runs obliquely across the dorsum from the junction of the middle and upper thirds of the thin vertebral border to opposite the middle of the glenoid cavity. At its commencement is a flat, triangular surface over which plays the aponeurosis of the *trapezius M.,* and at its free end is a projecting triangular plate (the **Acromion**) which overhangs the glenoid cavity. The spine is twisted in its course, so that the upper surface of the attached part is continuous with the under surface of the acromion. The *Supra-spinatus M.* lies against

each of these surfaces. The lower surface forms the upper limit of the infra-spinous fossa. The **Crest** of the spine is its free border, thick, commencing in the triangular surface, and gradually rising to end in the Acromion. Its upper margin is slightly but doubly curved and gives attachment to the *trapezius M.;* the lower margin is more abruptly curved, but also doubly, and gives attachment to the *deltoid M.* The **Acromion** is the free end of the spine, and runs outwards at first, then forwards and upwards; its plane is nearly horizontal, so that it is almost at right angles to that of the spine; it overhangs the glenoid cavity. Its *upper surface* is rough and subcutaneous, its *under surface* is smooth for a bursa between it and the *supra-spinatus M.* *Inner margin* has an articular facet for the clavicle, and at this joint there is sometimes a fibro-cartilage. *Outer margin* rough and rounded for attachment of *deltoid M.* At the tip is a roughness for an important ligament (the *coraco-acromial*).

Upper border extends from the upper angle to the root of the coracoid process at which position is a notch (**supra-scapular notch**) converted into a foramen in the recent state by a ligament (*supra-scapular ligament* or *ligament of the notch*) for the passage of a nerve and vein (*supra-scapular*). The upper border and part of the ligament of the notch usually give attachment to the *omohyoid M.*

Vertebral or **inner border** extends from the upper angle to the lower angle and opposite the root of the spine it projects. Above this projection the border gives attachment to the *Levator anguli scapulæ M.*, opposite the triangular surface at the root of the spine to the *rhomboideus minor M.*, below this to an aponeurotic arch, belonging to the *rhomboideus major M.*, and to some fibres of that muscle.

Axillary or outer border is thick and extends from the neck to the lower angle. The upper part is grooved for the scapular head of the *triceps M.;* below this is an oblique depression for the *teres minor M.*, the lower half gives attachment to the *teres major M.* A short distance below the neck is a transverse groove for the *dorsalis scapulæ Art.*

Angles. The outer angle is massive and presents for examination the **head** and **neck** with the **coracoid process** springing from the junction of the neck with the upper border. The **head** has on its free surface a pear-shaped articular cavity (**glenoid cavity**), shallow with raised margins deepened in the natural state by a thick fibrous ligament (*glenoid ligament*), pointed above, where a tendon is attached (*long head of biceps M.*). The **neck** is the compressed portion of bone supporting the head, distinct below but merging above into a hooked process. This, which is the **coracoid process,** is a curiously curved process running at first upwards, inwards, and forwards, then outwards and rather downwards, at right angles to its first part. Its *anterior* (or more correctly *inner*) *border* is rough for muscles (*pectoralis minor*, *coraco-brachialis*, and *short head of biceps*). Its *upper surface* is also rough for ligaments (*conoid* and *trapezoid* or *coraco-clavicular*), and its tip and outer border give attachment to the broad end of the *coraco-acromial* ligament.

The **upper angle** is well marked, and into it is inserted the *levator anguli scapulæ M.*

The **lower angle** is the most pointed and has on its posterior aspect the triangular surface for the *teres major M.;* on its anterior aspect that for the *serratus magnus.* Sometimes a slip for the *latissimus dorsi M.* rises from its posterior surface and the edge

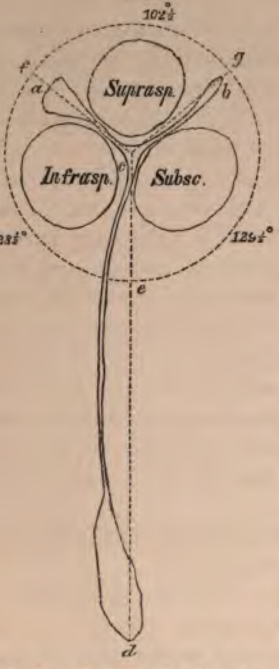
of that muscle crosses it, whether it takes origin here or not.

Articulations.—By the glenoid cavity with the head of the humerus, by the acromion with the clavicle.

Structure.—Thin and compact except in the head, neck, vertebral border and processes.

Development.—Usually by seven centres. That for the main part of the bone about the second month of fœtal life. Two for coracoid process: one of these appears in the first year, and is important, as it forms a large bone in many vertebrates. Two or more for the acromion, one for the lower angle, and one for the vertebral border. These appear about puberty. Sometimes there is a separate centre for the surface of the glenoid cavity.

Fig. 1.



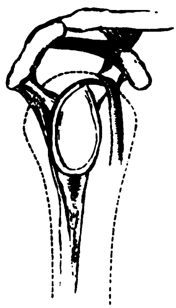
Section of scapula showing fossæ.

Mechanism.—The bone is arranged peculiarly, and although a thin structure, is admirably constructed to give attachment to the important muscles which control the movements of the arm. The spine rises from the dorsum leaving a deep fossa above and below, and

if a section be made through the bone vertically, it will be seen that the three fossæ around the axis of the glenoid cavity are curiously equal, so as to allow of equalizing the holding power of the muscles upon the head of the humerus (Fig. 1). It must be remembered that muscles are always acting, never totally at rest, and that they exercise a retaining power upon bones, a power supplemental to the atmospheric pressure, which will hold two surfaces in contact, as is shown in the schoolboy's sucker. Ligaments do not usually exert this retaining influence, but are provided for the purpose of limiting movement in certain directions, and are not constantly in a state of tension.

The glenoid cavity is peculiarly small, but thereby much greater freedom of movement is allowed at the shoulder-joint, and a fibro-cartilaginous rim surrounds the cavity, deepening it slightly.

Fig. 2.



Showing joint between head of humerus and coraco-acromial ligament.

It may be noticed here also that when the humerus is in contact with the glenoid cavity, the arms cannot be raised beyond a horizontal level when extended from the body, unless the scapula and clavicle be raised. This is owing to the projection of the acromion. Therefore, in carrying the hands up from the thighs to the top of the head, as in gymnastic exercises for opening the chest, the first half of the movement is accomplished at the shoulder-joint, the second half chiefly at the sterno-clavicular

articulation, and by rotation of the humerus at the shoulder, attended with rotation of the scapula round a pivot through its blade.

There is another joint also which often escapes notice. The great tuberosity of the humerus (Fig. 2) is received in certain positions by a strong and broad ligament joining coracoid process and acromion (coraco-acromial ligament). This occurs when the body rests partly upon the elbows or hands, as in pressing on a table.

If sections be made of the thicker parts of the bone, it will be seen that the fibres of the cancellous tissue are arranged definitely. In the accompanying diagram (Fig. 3) the fibres are seen to be forming curved lines which radiate from the glenoid cavity, and from a point immediately above it, and other lines are seen arranged concentrically with the surface of the glenoid cavity. We have here an evidence of the mechanical arrangement of the fibres in their radiation from the points of greatest pressure or traction —a beautiful provision for strength with lightness.

Fig. 3.

Section of neck of scapula and coracoid process, showing arrangement of bone fibres.

Method of determining right from left.—Hold the bone in the position it would occupy in your own body, the spine being posterior, the sharp angle downwards, and the glenoid cavity outwards; the

glenoid cavity looks outwards—*i.e.*, points to the side to which the bone belongs.

Points of importance :—

1. The bone lies very free and moveable, supported by and protecting the thorax.
2. The large spine projected backwards for muscles.
3. The acromion overhangs the shoulder.
4. The glenoid cavity is very shallow, for freedom of movement of the humerus, but is deepened in the natural state by a surrounding rim of fibro-cartilage.
5. The fossæ are arranged so as to give the attachment of muscles equally around the joint.
6. A large bursa exists under the acromion, and sometimes over it.

HUMERUS.—Plate II.

Synonyms: *E.* Upper arm. *G.* Oberarmbein n. *Fr.* L'os du bras. *L.* Humerus, os brachii.

Situation.—Occupies the upper arm extending from the shoulder to the elbow, and is the largest and longest bone of the upper extremity.

Shape.—It is a long bone with a globular head, placed obliquely and looking rather backwards for articulation with the scapula. A constricted, but not very distinct neck separates the head from the shaft. Two tuberosities and an intervening groove are found on the summit of the shaft, and are called respectively the great tuberosity (posterior), lesser tuberosity (anterior) and bicipital groove. The shaft is apparently twisted inwards. The lower part of the bone is called the base, and possesses two projecting masses (inner and outer condyles) and a curious articular surface.

Parts.—For the purpose of description, it is best to divide the bone into (1) an upper extremity, including the head, neck, tuberosities, and intervening groove; (2) shaft, and (3) lower extremity, including condyles and articular surface.

1. Upper extremity. The **head**, or globular portion, forms part of a sphere, is smooth for articulation with the glenoid cavity of the scapula, and looks obliquely upwards and backwards. It is separated from the rest of the bone by a slight constriction, the **anatomical neck,** which is a mere line above, but broad and distinct below; this gives attachment to the capsular ligament of the shoulder-

joint, and is perforated by foramina for nutrient vessels. The large mass at the upper and back part is called the **great tuberosity**, and extends from a deep groove in front, the bicipital groove, to the posterior aspect of the bone. Its *outer surface* is rough and continuous with the shaft. Its upper surface shows three large facets, the upper for the *supra-spinatus M.*, the middle for the *infra-spinatus M.*, the lower and posterior facet for the *teres minor M.* The **lesser tuberosity** projects from the front of the bone, internal to the bicipital groove, and is only slightly separated from the head. To its summit is attached the *subscapularis M.*, and the absence of any well-marked neck in this position is to be accounted for by the fact of the capsular ligament being defective under this muscle. The **bicipital groove** separates the two tuberosities, and is so called from its being occupied by the tendon of the long head of the *biceps M.*: it runs slightly inwards and forwards as well as downwards. The upper extremity is separated from the shaft by the **surgical neck,** the constricted portion of the bone below the level of the head.

2. **Shaft.** This is more or less prismatic, but rather cylindrical above, somewhat flattened from before backwards below. It is apparently twisted inwards, but like other long bones, this appearance of twisting is really due to moulding of the surface. It has three borders and three surfaces. *Anterior border* extends from the front of the great tuberosity, and ends below at a fossa on the anterior surface of the base (coronoid fossa). It is rough above, where it forms the outer margin of the bicipital groove, and here gives attachment to the *pectoralis major M.*;

rough in the middle, where it forms the edge of the deltoid impression; smooth below, where the *brachialis anticus M.* rises from it. *Outer border* extends from the back of the great tuberosity to the outer condyle. It is smooth and indistinct above, where it is covered by the *deltoid M.;* rough in the middle, forming the back edge of the deltoid impression; smooth below this, where it forms part of the musculo-spiral groove; prominent in its lower third, where it is called the **outer condyloid ridge** and gives attachment to an intermuscular septum, and its front edge to the *supinator longus M.*, and *extensor carpi radialis longior*. *Inner border* from the lesser tuberosity to the inner condyle. Above it is well marked and forms the inner edge of the bicipital groove for the attachment of the *teres major M.*, and *latissimus dorsi M.*, which extends also into the bottom of the groove; in the middle is a rough line about one to two inches long for the *coraco-brachialis M.*, and here is usually to be seen a canal running downwards for a large nutrient artery; it is prominent in its lower fourth, and constitutes the **inner condyloid ridge** for an intermuscular septum, and the origin of a muscle, the *pronator radii teres.*

The posterior surface is internal above, and is the space included between the outer and inner borders. It is convex above, slightly grooved by an oblique shallow groove (**musculo-spiral groove**) which is better seen towards the outer border: this runs obliquely downwards and outwards, and separates the upper and lower humeral heads of the *triceps M.*, and lodges the *musculo-spiral* nerve and *superior profunda Art.;* the lower part of this surface is flattened, and is traceable into a large depression (the **olecranon fossa**). *Inner surface* between anterior and inner

borders commences above, in the bicipital groove, is broader in the middle, and narrow again below; the lower half gives attachment to the *brachialis anticus M.* *Outer surface* between anterior and outer borders, smooth and rounded above, presents above the middle a rough triangular surface, the **deltoid impression,** for the insertion of the *deltoid M.;* below this, grooved by the continuation of the musculo-spiral groove, and becomes rather anterior in its lower third; the lower half gives attachment to the *brachialis anticus M.*

3. Lower extremity. This is somewhat curved forward and flattened. In front is seen a depression, the **coronoid fossa,** so called because the coronoid process of the ulna fits into it in flexion; and sometimes a smaller depression to the outer side of this for the head of the Radius. Behind is a still larger and deeper depression, the **olecranon fossa,** into which the olecranon process of the ulna fits in extension, and the bone is extremely thin, or even perforated, between these two fossæ. Of the two lateral prominences, the inner projects more than the outer. This **inner condyle** gives attachment to the *superficial flexor muscles* of the forearm, and to the *internal lateral ligament* of the elbow-joint. The **outer condyle** is less prominent, partly in consequence of the outer condyloid ridge being very pronounced, and it is so closely connected with the outer articulating surface or capitellum, that a fracture through it almost necessarily involves the elbow-joint, whereas the inner condyle can more readily be broken off without the articular surfaces being injured. To the outer condyle are attached the *superficial extensors of the forearm,* and there is a depression close to the articular surface for the *external lateral ligament.*

The articular surface occupies the base of the bone, and projects lower down on the inner side; it is broader anteriorly than posteriorly, extends to about an equal height in front and behind; the inner part or *trochlea* is continuous with both coronoid and olecranon fossæ, the outer part or *capitellum* exists only in front. The **capitellum** is the rounded portion in front of the outer condyle, lost behind in a point a little behind an imaginary median transverse line, separated from the rest of the articular surface by a shallow groove. It is for articulation with the radius, but only when the forearm is flexed. The **trochlea** is the large pulley-like surface which lies below the axis of the shaft; it does not extend to the condyles; it has a deep median groove which extends from the coronoid to the olecranon fossæ, and therefore runs rather obliquely, so that in flexing the forearm it is naturally thrown towards the body. The inner lip of the trochlea has the articular surface extended over it in front but not behind, but the outer lip is only well marked behind to provide for the greater steadiness required when the forearm is extended. The outer lip of capitellum also has the articular surface extended over it. The margins of the articular surfaces give attachment to the capsule of the joint.

The things seen in order across the lower end are therefore :—1. Inner condyle. 2. Inner lip of trochlea. 3. Groove of trochlea. 4. Outer lip of trochlea. 5. Groove between trochlea and capitellum. 6. Convexity of capitellum. 7. Outer lip of capitellum (5, 6, and 7 are only seen in front). 8. Outer condyle.

Development.—From seven centres, seen, one in shaft in about the 5th week of fœtal life; head, 1st or 2nd year; great tuberosity, 2nd year; radial portion of

base, 2nd year; inner condyle, about 5th year; trochlea, 12th year; and outer condyle, 13–15 years. Sometimes an additional centre is seen in the lesser tuberosity.

Articulations.—With three bones—scapula above, radius and ulna below.

Mechanism.—The first thing which strikes an observer is the much greater size of the head than of the socket in which it is placed. Moreover, one cannot help being struck with the shortness of the neck compared with what we shall afterwards find in the corresponding bone in the lower extremity (the femur), the smallness of its projections or tuberosities, and their nearness to the joint. What are the results of these arrangements? (1) Great freedom of rotatory and every other movement, but great liability to displacement—and, as this is the most freely moving joint of the body, so it is the most frequent seat of dislocation. (2) The muscles acting upon the humerus, being so close to the fulcrum or turning-point, gain immensely in the space through which they move the long arm of the lever: they lose, however, in strength. But it must be remembered that mere strength is not the only requirement in animal mechanics, but compactness of parts, and provision for rapidity and extent and variety of movement.

The strength of the bone is increased by its external and internal structure. Looking at it from the front or back, it is seen to be doubly curved like an italic *f*: looking at it from the side, it is curved considerably forward below. These curves provide an elasticity which must be of great importance in protecting the bone from injury in the many occasions when it is jarred in its long axis.

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There appears to be a twisting of the bone inwards, but this may more accurately be called a moulding of the surface; still it must not be overlooked, as it probably exerts a definite influence upon the mechanism of the bone by adding to its elasticity in the same way as a spiral spring. This spiral moulding of the surface is seen in nearly all the long bones.

Fig. 4.

Head of Humerus—showing arrangement of bone-fibres. The dark line across the bone indicates the line of epiphysis.

In its internal structure (Fig. 4) we see reason to admire the mechanics of nature, for we find a truly marvellous combination of lightness, strength, elasticity, and adaptation to the varied movements of the joint. Examining the upper end, we find that springing from the compact shell of the shaft are curved fibres, arching in various but in definite directions, running from this firm support in a series of divergent curves, whose ends can be best traced to those surfaces which bear the greatest pressure. It must be borne in mind that there are two joints into which this part of the bone enters—the shoulder-joint, and that under the coraco-acromial ligament, and consequently there are two surfaces of pressure—one that of the globular-head, the other, that of the upper aspect of the great tuberosity. Now, the divergent curves referred to are definitely related to these two surfaces; those starting from the outer side of the bone terminate partly by impinging upon the articular

surface, especially its lower half, and partly by entering the great tuberosity and terminating perpendicularly to its upper surface. Those starting from the inner side of the shaft in part interlace with the first set, but the upper and more numerous curves terminate in the articular surface, especially its upper half. This combination of curved fibres has the effect of opposing some one or more sets perpendicularly to the point of contact in whatever position the shoulder is placed, and seeing how intimately the cross-curves are connected, the whole structure presents a simple but wonderful lattice-girder arrangement, far surpassing our most ingenious contrivances. It will be useful to compare this with the arrangement found in the femur, and a curious similarity of construction will be found.

Looking next at the lower end of the bone (Figs. 5, 6, 7) we see similarly curved lines impinging upon the articular surfaces, or strengthening the bone by their lattice-like arrangement, as seen in the condyles; but it must be noticed that these lines are always curved. In the median section this is beautifully shown, and the effect in this case is to oppose certain fibres always perpendicularly to the surface, and yet insure their being elastic and but little liable to injury—a result which would not be obtained if the lines were straight, even though they radiated.

Means of distinguishing right from left.—Hold as if upon your own body, with the globular end upwards and the trochlear surface downwards, with the tuberosities in front and large olecranon fossa behind, the great tuberosity, and the less prominent outer condyle will

be on the outer side—*i.e.*, will point to the side to which the bone belongs.

Fig. 5.

Lower end of Humerus.
Section from side to side.

Fig. 6.

Humerus.
Vertical section
through middle
of lower end.

Fig. 7.

Humerus.
Section through
inner condyle.

Points of importance :—

1. Bone apparently twisted inwards below.
2. Large head, small neck, two tuberosities.
3. Tuberosities separated by bicipital groove.
4. Peculiar articular surface below. Trochlea continuous with both fossæ, capitellum only on front of outer condyle.
5. Inner condyle very prominent; outer more in relation with articular surface.
6. Nutrient artery runs towards elbow.
7. Mechanical structure.

RADIUS.—Plate III.

Synonyms: *E.* Small bone of the arm. *G.* Speiche Armspindel. *Fr.* Rayon. *L.* Focile minus.

Situation.—The Radius is one of the two bones composing the forearm and is placed on the outer side. It has only a slight connexion with the humerus above, but at its lower end is large and comes into contact with the first row of carpal bones.

Shape.—A long bone with a small upper end or head surmounting a constricted neck. Its shaft prismatic and curved. Its base large and somewhat quadrangular, ending on the outer side in a pointed process —the styloid process.

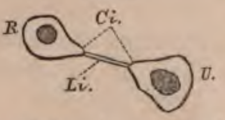
Parts.—(1) Upper extremity, including the head, neck, and a tuberosity. (2) Shaft having three borders and three surfaces. (3) Lower extremity.

1. **Upper extremity.** The **head** can be easily felt in one's own arm by placing the thumb inside the outer mass of muscles in front of the bend of the elbow, and the fingers below the outer condyle behind, and rotating the hand: it has on its summit a concave smooth surface, for articulation with the outer condyle of the humerus in flexion. Surrounding the head is a smooth surface, continuous with that just noticed above, about a quarter to a third of an inch broad, but best marked on the inner side, where it comes into contact with the lesser sigmoid cavity of the ulna; the rest of the smooth surface is for the orbicular ligament of the radius, which allows of the head of the bone rotating on its own axis. The **neck** is the constricted portion immediately below

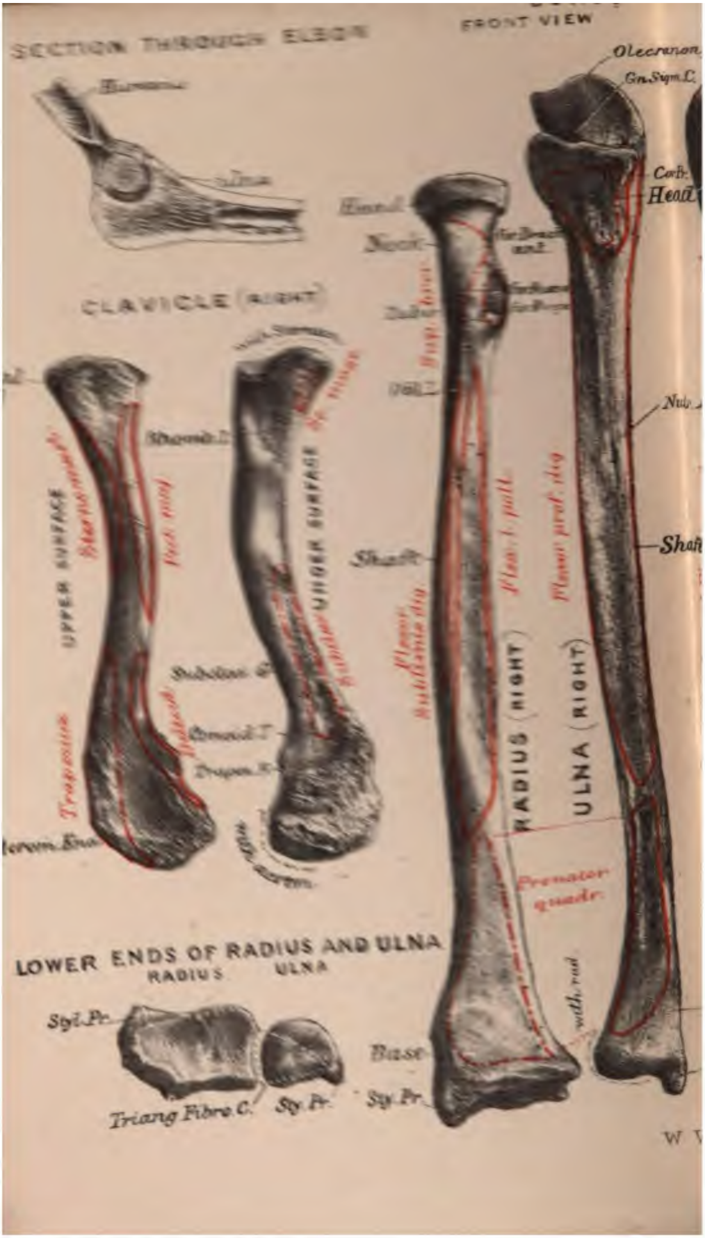
the head. The **tuberosity** is a flattened prominence on the inner side just below the neck; its front part is smooth for a *bursa;* its back part is rough, for the insertion of the *Biceps M.*

2. **Shaft** curved with its convexity looking to the outer side. *Inner border* extends from the back of the Tuberosity, forms a sharp edge in the greater part of its length for the *interosseous membrane*, divides below about one to two inches from the base, and ends on each side of a small concave articular surface for the ulna. This border is concave. *Anterior border* extends from the front of the Tuberosity, running at first as a distinct oblique rounded ridge, the **oblique line,** to the middle of the outer side of the bone. To this oblique line is attached the *flexor sublimis dig. M.* The border then becomes ill-defined, and passes in front of a rough surface (for the *pronator teres M.*) and ends below as a sharp ridge in front of the Styloid process. *Posterior border* ill-defined above, well-marked in the middle, and ends in a prominent ridge fully half an inch behind and to the inner side of the Styloid process. *Anterior surface* between inner and anterior borders extends from the Tuberosity to the base, narrow above, becoming broader in the middle, where it is slightly concave for the *flexor longus pollicis M.*, and still broader and flattened in its lower third for the *pronator quadratus M.;* at its lowest limit it projects forward. Near the inner sharp edge in its upper half is seen a foramen for the *nutrient artery* which runs towards the head of the bone. *Posterior surface*

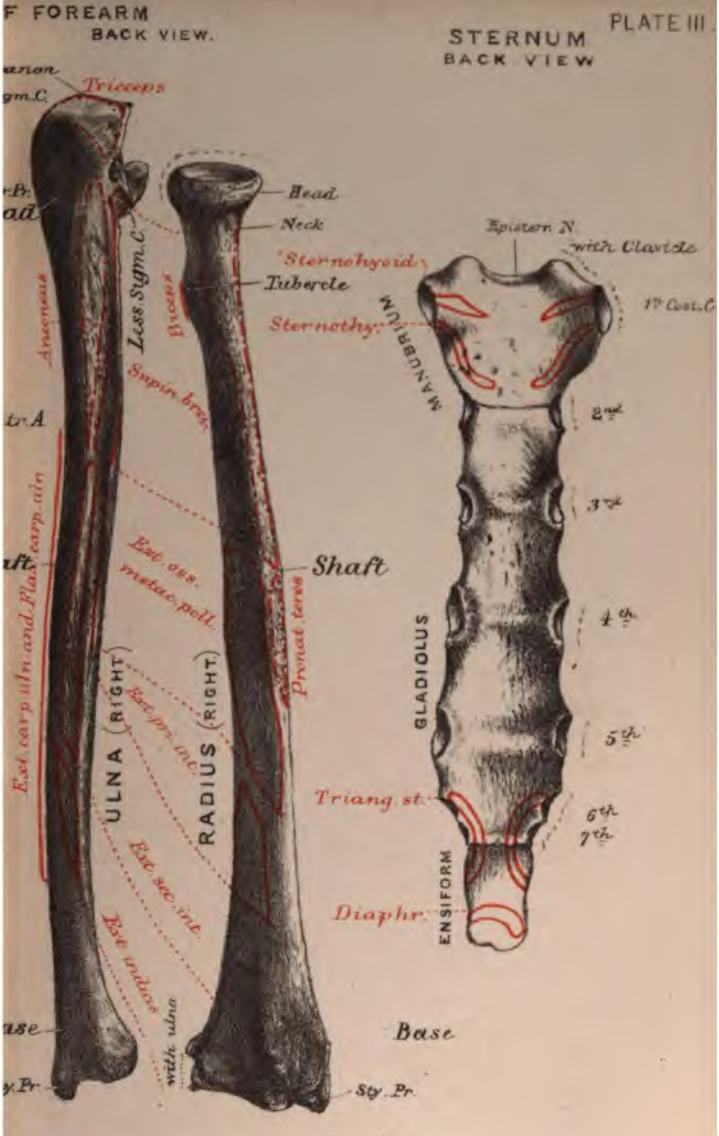
Fig. 8.



Horizontal section of the bones of the forearm. *R.* Radius. *U.* Ulna. *Ci.* Interosseous Crests. *Li.* Interosseous Ligament.



FRONT VIEW
SECTION THROUGH ELBOW
Olecranon
Gn.Sigm.C.
Head
Neck
Shaft
CLAVICLE (RIGHT)
UPPER SURFACE
UNDER SURFACE
Trapezius
Pronator quadr.
RADIUS (RIGHT)
ULNA (RIGHT)
LOWER ENDS OF RADIUS AND ULNA
RADIUS
ULNA
Styl.Pr.
Triang Fibro.C.
Sty.Pr.
Base
Sty.Pr.


F FOREARM
BACK VIEW.
STERNUM
BACK VIEW
Triceps
Head
Neck
Less Sigm.C.
Sternohyoid
Tubercle
Biceps
Sternothy.
Supin.brev.
Ext.oss. metac.poll.
Shaft
Pronat.teres
Ext.carp.uln.and Flex.carp.uln
ULNA (RIGHT)
RADIUS (RIGHT)
Ext.pr.int.
Ext.sec.int.
Ext.indicis
with ulna
Base
Sty.Pr.
Epistern.N.
with Clavicle
1st Cost.C.
MANUBRIUM
2nd
3rd
4th
5th
6th
7th
GLADIOLUS
Triang.st.
ENSIFORM
Diaphr.

& C° Lith

between inner and posterior borders, rounded above, sometimes marked by an oblique line which runs from the back of the tuberosity to the middle of the outer side of the bone, and indicates the limit of attachment of the *supinator brevis M.*; rough and sometimes hollowed in rather more than its middle third for the *deep extensor muscles*; well marked and concave from side to side at its lower end for lodging the tendons of *extensor secundi internodii pollicis M.* (in a separate deep groove close by the posterior margin) and the *extensor communis* and *extensor indicis Ms.* *Outer* surface rounded, smooth above for the *supinator brevis M.*, rough in the middle for the *pronator radii teres M.*, irregular and grooved longitudinally below; one of these grooves is placed rather to the front of the styloid process, and is double and lodges the *extensor ossis metacarpi pollicis* and *extensor primi internodii Ms.*; the other is placed rather behind the styloid process, is also double, and lodges the tendons of the *extensor carpi radialis longior* and *brevior Ms.* Into the styloid process itself is inserted the *supinator longus M.*

3. **Lower extremity,** quadrilateral, with the **styloid process** projecting downwards on the outer side for the *external lateral ligament* of wrist-joint. Three surfaces, *anterior*, *posterior*, and *outer*, have been already described in continuation with those of the shaft. The *inner surface* is concave and triangular, rough above for ligamentous fibres, smooth and articular below for the lower radio-ulnar articulation; the lower edge of this surface is sharp for attachment of the *triangular fibro-cartilage.* *Under*, or *articular surface*, rather triangular in outline, concave in both directions, traversed by a faint ridge from before backwards, which marks off a smaller inner quadrilateral surface for articulation with the semilunar bone, and a

larger outer triangular surface for the scaphoid bone.

Articulations.—By its summit with capitellum on the outer condyle of the humerus, but only during flexion; by the inner side of the head with the lesser sigmoid cavity of the ulna; by its lower surface with the carpus; and by the small concave articular surface on the inner side of the base with the lower end of the ulna.

Development.—From three centres. Shaft, early, about 5th week of fœtal life; lower end, 2nd year; head, 5th year, but the head unites with the shaft (15 years) earlier than the base (20–25 years). Notice here that the nutrient artery runs towards the head, or the epiphysis which is the first to unite, and that this is the general rule in long bones.

Mechanism.—This bone enters largely into the formation of the wrist-joint, but only comes into contact with the humerus when the arm is bent. It presents certain curves, the main one with the concavity directed towards the ulna, another with the concavity forwards, seen on the anterior surface below. These contribute to the elasticity of the bone. Moreover, the inner edge forms a rib, or girder, increasing greatly the strength of the bone, and when excessively bowed, as in rickets, this girder is proportionally increased. It is in the bowed portion that fracture usually occurs. Unlike most other long bones its apparent twist is slightly outwards.

Looking at the upper end we find that it is evidently arranged for rotation upon its central axis. Looking at the lower end it is evident that rotation occurs round a point which corresponds with the depression under the styloid process of the ulna,

and this will be referred to more fully after considering the ulna. The lower end is expanded evidently for the leverage of muscles, and for the support of the carpus.

When a blow is received on the hand with the arm outstretched, force is transmitted through the radius, not to the humerus directly, but the fibres of the interosseous membrane (Fig. 20) which run purposely downwards to the ulna drag upon that bone and force it against the humerus.

If a section be made of the bone through the head (Fig. 9), it will be seen that the fibres of the cancellous tissue which compose it are arranged with wonderful regard to its strength. They spring from the thicker layer of the shell, and form diverging curves which cross one another, and the upper ones terminate upon

Fig. 9.

Radius. Upper end. Diagram of structure.

Fig. 10.

Radius. Diagram showing structure of lower end.

the articular surface in such manner that some are always vertical to the line of pressure, and the combination of these curves provides the most perfect lattice-girder that can be imagined.

A section of the shaft shows the shell to be thickened, but in those bones where the structure is atrophied, a distinct arrangement of bone-fibres in interlacing arches may be traced. The inner edge is usually the thickest, and is of importance, as acting in the manner of a T girder.

At the lower end (Fig. 10), where the bone is extremely porous, it will be noticed that a very thin plate of bone lines the articular surface, but great strength is insured by the arrangement of the bone fibres. They are still slightly curved, but in opposite directions, towards the opposite sides, this convexity being towards the middle line of the bone, and the middle ones interlacing. Other curved lines are seen running nearly horizontally.

Method of distinguishing right from left.—Hold, as if in your own arm, with the head upwards and base downwards, the flatter surface in front, and convex side of the base behind; the styloid process and convex border of the shaft will be on the outer side—*i.e.*, will point to the side to which the bone belongs.

Points of importance :—

1. Anterior surface concave, but flat below, and broad, to afford large attachment to *pronator quadratus M.*

2. Posterior surface rather convex, and presenting a deep oblique groove towards lower end.

3. Tuberosity has smooth surface in front for bursa, and rough surface behind for insertion of *biceps*.

4. Rough surface for *pronator teres*, oblique ridge for *flexor sublimis*.

5. Two articular surfaces at lower end at right angles to one another.

6. Mechanical arrangement at each end.

ULNA.—Plate III.

Synonyms: *E.* Cubit. *G.* Das Ellenbogen-bein. *Fr.* Os du coude. *L.* Cubitus (κυβιτον), focile majus.

Situation.—One of the two bones of the forearm, forming the chief means of connexion between the forearm and humerus, but below only small and not coming into direct contact with the carpus.

Shape.—Massive above, ending in a beaked process (the olecranon) which overhangs a large articular cavity (the great sigmoid cavity); the lower or anterior limit to this cavity is formed by another marked process (the coronoid process). Below this the shaft gradually diminishes in size and is doubly curved and ends in a rounded base, from the inner and posterior side of which a small process, the styloid, projects downwards. The shape is therefore almost the reverse of that of the radius, which is small above and large below.

Parts.—(1) Upper extremity, including olecranon, coronoid process, and great and lesser sigmoid cavities. (2) Shaft. (3) Lower extremity with styloid process.

1. **Upper extremity.** The mass which forms this is deeply hollowed out by the great sigmoid cavity, which is overhung by the olecranon, or tip of the elbow, the direct termination of the shaft: the under lip of the cavity is formed by the process called coronoid (κορώνη, a crow's beak).

Olecranon (ὠλένης κράνον, tip of the elbow) is continuous with the shaft, is large and curved forwards. It is contracted just where it joins the shaft, and it is

by the olecranon that the ulna exceeds the radius in length. This portion of the bone is homologous with the patella in the lower extremity. Its posterior surface is smooth and triangular and is subcutaneous; over it is sometimes a bursa; its upper surface is uneven, the greater part being for the insertion of the *triceps M.*, but a narrow part is left near the free margin for the insertion of the posterior ligament of the elbow-joint; its articular surface forms part of great sigmoid cavity, is concave from above downwards, convex from side to side owing to a median ridge which runs obliquely. This articular surface is continuous with that of the coronoid process and lesser sigmoid cavity, but the limit of each part is indicated along the margins by a rough depression more or less complete, and occupied in the natural state by synovial folds.

Coronoid process rather triangular, projecting forwards, its anterior surface rough for insertion of *brachialis anticus M.*; its outer surface has upon it a shallow concave depression, the **lesser sigmoid cavity**; its inner edge is sharp and gives attachment to some muscular slips (second head of *pronator radii teres, flexor sublimis digitorum*); the inner surface is rather grooved; its upper or articular surface is concave from before backwards, concave from side to side owing to a median ridge.

Great sigmoid cavity occupies part of olecranon and coronoid processes, is deeply concave from above downwards, convex transversely as the result of a nearly median ridge which leaves the inner part larger than the outer, and which fits into the trochlea of the humerus; the upper or olecranon portion is separated from the lower by a notch on each side.

Lesser sigmoid cavity is continuous with the

greater, occupies the outer side of the coronoid process; to its two extremities are fixed the two ends of the *orbicular ligament* which holds the radius in position against the lesser sigmoid cavity.

2. The **shaft** has three borders (anterior, outer and posterior) and three surfaces (anterior, posterior and inner.) *Anterior border* continuous with the inner edge of coronoid process and extends to the front of the styloid process on the base of the bone. *Outer border* must be traced from behind the lesser sigmoid cavity, forms a sharp edge except at its lower end, where it is lost on the articulating surface for the radius; it gives attachment in nearly its whole length to the *interosseous membrane*. *Posterior border* well marked in the greater part of its length, extends from the triangular surface on the back of olecranon to the back of the styloid process and gives attachment to an aponeurosis for muscles in front of and behind the forearm (*extensor carpi ulnaris* and *flexor carpi ulnaris Ms.*). *Anterior surface* commences above on the outer side of the coronoid process at the root of which is a **tubercle** for the *oblique* radio-ulnar ligament; below this the surface becomes flattened or concave for the *flexor profundus digitorum M.*, and the lower fourth is rounded for the *pronator quadratus M.* The *posterior surface* between the outer and posterior margins shows behind the lesser sigmoid cavity, a triangular surface for the *anconeus M.*, which is limited below by the **oblique line** of the ulna; the lower three-fourths show a longitudinal ridge which indicates the limits of attachment of muscles. *Inner surface* smooth, apparently twisted, gives attachment to the *flexor profundus digitorum M.*

3. **Lower extremity,** small, rather rounded, but with a flat under surface from the inner side of which projects the styloid process. There are two articular

surfaces, the *basal* or *lower* being nearly circular for articulation with the triangular fibro-cartilage of the wrist-joint, the *lateral* covering nearly half the circumference of the base on the outer side and being for articulation with the sigmoid cavity of the radius. The **styloid process** is small and gives attachment by its apex to the internal lateral ligament; it is grooved behind for the *extensor carpi ulnaris M.*, and between it and the basal articular surface is a depression for the triangular fibro-cartilage which supports the base of the bone and connects it with the radius.

Articulations.—With the humerus and radius above, with the radius below. It does not come in contact with the carpal bones below, but is separated from them by the triangular fibro-cartilage.

Development.—By three centres, for shaft, base, and tip of olecranon, resembling the radius in times of appearance and union.

Mechanism.—First bear in mind that the ulna is the only bone in contact with the humerus in most of the positions of the limb, and that the great hinge-joint of the elbow is formed between those two bones. Looking at the general conformation of the ulna you notice the expanded head and the rather tapering shaft. The latter is provided with greater resisting power to force applied in its long axis by its double curve, seen well in Plate III., and by its ribbed edge. At its upper end the trochlea or pulley surface is not so simple as at first sight appears, and the motion here is not simply antero-posterior but with a curved direction inwards, so that in mid-flexion the hand is thrown across the body. By this means the limb is made more available for protection and feeding.

If we look next at its articulation with the radius,

we notice that the cup-shaped lesser sigmoid cavity allows rotation of the head of the radius upon an axis which is in the centre of the head of the radius; at the lower radio-ulnar articulation the conditions are altered and the radius rotates round a point near the styloid process of the ulna. The result of this is to permit free movements of pronation and supination of the hand without displacement at the elbow-joint. In Fig. 11 the real axis of rotation of the radius is the line *a*, *b*. This line represents the axis of a cone of which the base is *c*, *d*, and the truncated apex is *e*, *f*. "The centre of the truncated apex corresponds with the centre of the head of the radius, and the centre of the base coincides with the centre of the circle of which the sigmoid cavity is a segment. If the prolonged axis of the head of the radius fall upon any other point than the centre of the sigmoid curve, there would necessarily be a slight hinge-like motion at the upper joint, whenever pronation occurred at the lower." (Ward).

Fig. 11.

Diagram showing motion of radius round an axis, *a b*, passing through head of radius and base of ulna.

The two large processes, olecranon and coronoid, fit into the cavities of the humerus in extreme flexion and extension (Pl. III.). These processes may be broken off by injury, and dislocation can hardly occur without fracture of one or other process.

The shape of this bone being peculiar and evidently intended for special mechanical purposes, the arrangement of its internal structure becomes of considerable

importance. In a vertical section of the upper end from before backwards (Fig. 12), we are able to see that the same principle is carried out as in other bones already noticed, that it is built up essentially of curved columns more and more diverging, and that the uppermost of these are concerned in the support of pressure at the joint-surface. Those springing from the front

Fig. 12.

Ulna. Plan of construction seen in vertical section through great sigmoid cavity and olecranon.

Fig. 13.

Ulna. Section of upper end from side to side.

wall of the shaft receive the pressure which occurs when the arm is extended as in striking "from the shoulder," or in pressing with the arms straight; those springing from the back wall of the shaft impinge upon the middle of the articular surface in part, but part run into the olecranon, and so would receive the pressure acting through the length of the bone when the arm is bent and the elbow rests on the table.

In a section of the same part (Fig. 13) from side to side we see a somewhat similar arrangement of cross-

ing parabolic curves forming arches more and more pointed as they are traced upwards. There does not appear to be any clearly defined arrangement in connexion with the lesser sigmoid cavity, and from this it is evident that very little pressure occurs between the two bones at this joint.

In examining a simple transverse section through the head, the curved columns are again found to be in relation with the articular surface for the humerus and not for the radius; they impinge vertically upon the former surface.

At the lower end (Fig. 14) the arrangement consists of two sets of divergent curves, one of which ends upon the lower articular surface which presses upon the triangular ligament, and the other set runs into the styloid process.

When a transverse section is made through this end the main direction of the fibres is found to be parallel with the articular surface, and not impinging upon it—another evidence of this absence of much pressure at the articulation.

Fig. 14.

Ulna. Section through lower end. Plan of construction.

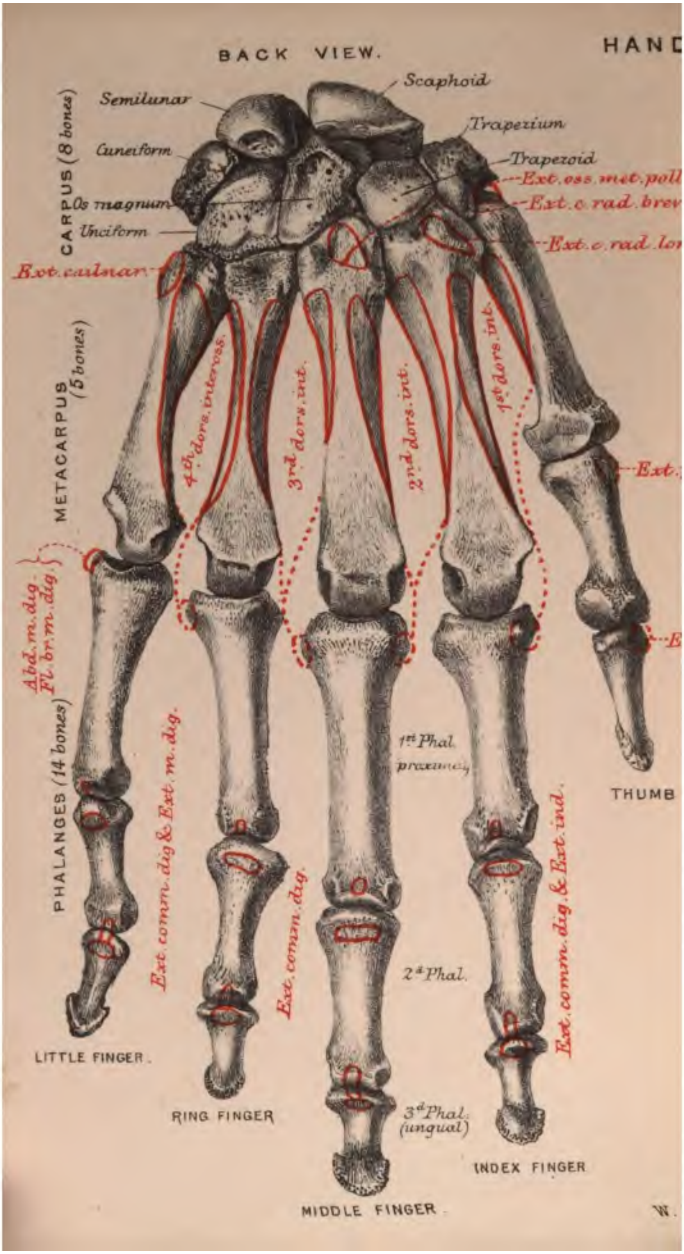
Means of distinguishing right from left.—Hold the bone in the position it would naturally occupy in the body, with head upwards and larger olecranon process posteriorly; the lesser sigmoid cavity and sharp edge of the shaft are on the outer side—*i.e.*, to the side to which the bone belongs.

Points of importance.—1. Upper end articulates freely with humerus, and presents two large projections—coronoid and olecranon.

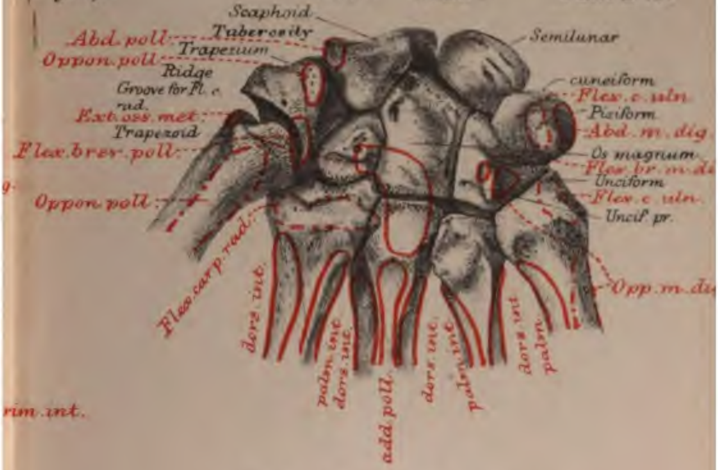
2. Lower end small, separated from carpus by triangular ligament.

3. United to radius above and below peculiarly, and along its shaft by a strong interosseous membrane: above the ulna receives the side of the head of the radius in a fossa, below it fits into a shallow fossa on the radius.

4. Mechanism.



HAND
BACK VIEW.
CARPUS (8 bones)
Semilunar
Scaphoid
Trapezium
Cuneiform
Trapezoid
Ext. oss. met. poll
Os magnum
Ext. c. rad. brev
Unciform
Ext. c. rad. lo
Ext. c. ulnar
METACARPUS (5 bones)
4th dors. inteross.
3rd dors. int.
2nd dors. int.
1st dors. int.
Ext.
Abd. m. dig.
Fl. br. m. dig.
PHALANGES (14 bones)
Ext. comm. dig & Ext. m. dig.
Ext. comm. dig.
1st Phal.
THUMB
Ext. comm. dig. & Ext. ind.
2d Phal.
LITTLE FINGER.
RING FINGER
3d Phal. (ungual)
INDEX FINGER
MIDDLE FINGER.



rim. int.

Arch of Carpus, seen from above.

t. sec. int.

Second row of Carpal Bones

& Co lith

CARPUS.—Plate IV. and Figs. 15, 16.

Synonyms: *E.* Wrist. *G.* Die Handwurzel. *Fr.* Le poignet.

Situation.—The carpus consists of eight small bones, firmly bound together, but allowing of gliding movement between them. They are interposed between the forearm and metacarpus, and belong rather to the hand.

Shape.—The carpus as a whole is arched above and concave forwards, and can be divided for convenience sake into *two rows.* The *upper* consists of four bones, the scaphoid (nearest to the thumb side), the semilunar, the cuneiform, and the pisiform projecting forward on the little finger side. The *second row* consists also of four bones, the trapezium, which articulates with the thumb, the trapezoid, the os magnum, and the unciform, whose hooked process projects forwards beneath the pisiform bone. The shape of the separate bones offers at first sight but little means of determining them separately, but on closer examination each has some distinctive feature. It must be noticed that each bone has six *surfaces,* and of these the *anterior* and *posterior* are rough for ligaments, and owing to the carpus being arched forward, the posterior surfaces are naturally broader than the anterior. The *upper* and *lower* are in all cases (except that of the pisiform) smooth and covered with cartilage; the upper surfaces convex because the first row is arched and fits into the radius, and the second row is also arched, and fits into the first in rather more than half its extent; the under surfaces are consequently generally concave. The *inner* and *outer* surfaces are mostly smooth for articulation

with adjacent bones, otherwise they are rough and tubercular. On the back of the first row it is worth while to notice a horizontal groove which marks all except the pisiform; it is for the posterior ligament of the wrist-joint. It must be borne in mind in examining the bones separately that each contributes to the mechanical arrangement of the carpus, and that certain arches are provided to give strength to a part so exposed to injury as the wrist. At first, then, for this purpose notice the *double arch* formed by the upper row of bones—one with the convexity upwards, the other with its convexity towards the dorsum, its two ends being the pisiform and tuberosity of the scaphoid in front. Next notice in the second row that the inner two bones (on the little finger side) fit into the arch of the first row, but that the outer two bones together form a cup which receives the end of the scaphoid. Lastly, notice that the metacarpal bones articulate in a rather curious manner with the carpus—the first metacarpal with one, the second with three, the third with one, the fourth with two, and the last with one, and that the second and third have their adjacent sides prolonged upwards on the dorsum.

Determination.—Various methods have been adopted for assisting the student to determine the bones when separated, but any plan is faulty and likely to mislead rather than help, unless it follows some general rule for all the bones. The plan here proposed is to fit, as it were, each bone in an articulated hand, suspended before the student with the palm facing him. Sup What-ever therefore points to the inner side points to the side to which the hand belongs. The position would correspond with the front view in PLATE IV.

SCAPHOID.—Plate IV. and Figs. 15, 16.

Synonyms: *G.* Das Kahnbein, Schiffbein. *Fr.* Le scaphoide. *L.* Naviculare, scaphoideum.

Known by its boat-shaped socket, for the head of os magnum; by the horizontal groove between the two convex surfaces, for the posterior ligament of wrist; by its projecting tubercle for the external lateral ligament of wrist, anterior annular ligament, and *abductor pollicis M.*, and by a thin convex edge which separates the socket from the upper convex articular surface, and which is itself smooth for articulation with the semilunar. It is the largest and outermost of the first row, and is placed rather obliquely with its long axis downwards and outwards. *Upper surface* convex, smooth, rather triangular, for articulation with the radius. *Lower surface* smooth, convex, the outer part for articulation with trapezium, the inner with the trapezoid. *Dorsal surface* rough, grooved for posterior ligament of the wrist. *Palmar surface* hollow, ending in a *tubercle* at the outer extremity for the anterior annular ligament, external lateral ligament, and *abductor pollicis M.*; this tubercle overhangs the lower convex articular surface. *Outer surface* rough, continuous with tubercle. *Inner surface* shows the socket for the head of the os magnum, and above this a small articular facet for the semilunar; this is continuous with the upper articular facet.

Determination.—Hold the bone so that the larger convex surface looks upwards, the socket surface downwards and rather inwards, the narrow grooved dorsal surface away from you; the thin convex edge points towards the cuneiform—*i.e.*, towards the inner side of the hand—*i.e.*, to the side to which the hand belongs.

SEMILUNAR.—Plate IV.

Synonyms: *E.* Lunar. *G.* Das Mondbein. *Fr.* Le semilunaire. *L.* Os semilunare, lunatum.

Known by its two semilunar surfaces.

It is situated in the middle of the upper row, between the scaphoid and cuneiform. *Upper surface* smooth, convex, with four edges; it articulates with the radius. *Lower surface* deeply semilunar, broader from before backwards, articulates with os magnum, and by a narrow facet near the inner edge with the unciform. *Dorsal surface* rough, grooved transversely for ligaments. *Palmar surface* rough, rounded, and of greater extent than the dorsal. *Outer surface* having a narrow semilunar facet for the scaphoid. *Inner surface* marked by a four-sided smooth facet for the cuneiform.

Determination.—Hold with the large four-sided convex surface upwards, the large semilunar facet downwards for the os magnum, the narrow grooved non-articular (dorsal) surface away from you, and the rounded larger non-articular surface facing you: the narrow convex edge of the upper surface points towards the cuneiform—*i.e.*, the inner side—*i.e.*, towards the side to which the hand belongs.

CUNEIFORM.—PLATE IV.

Synonyms: *G.* Das Pyramidenbein, Dreisitigebein. *Fr.* Le pyramidale. *L.* Os triquetrum, pyramidale, cuneiforme.

Known by its wedge-shape, its small, round, distinct facet for the pisiform, and by its concavo-convex surface for the unciform.

It is placed at the inner or ulnar end of the first row, and has the pisiform projecting from its front surface. Its *upper surface,* which is rather internal, shows an inner part, non-articular for ligaments, and an outer, articular for contact with the triangular fibro-cartilage of the wrist-joint, but it does not come in contact with the ulna. *Lower surface* is rather external, is concavo-convex for the unciform. *Dorsal* rough, grooved transversely for ligaments. *Palmar* flat, non-articular above, but showing a distinct circular facet below for the pisiform. *Outer* four-sided, articular for semilunar. *Inner* rough for the internal lateral ligament of the wrist.

Determination.—Hold with the base of the pyramid upwards and slightly outwards, the flat circular facet for the pisiform occupying the lower half (or apex) of the triangular (palmar) surface which faces you; the large non-articular surface looks to the inner side—*i.e.*, to the side to which the hand belongs.

PISIFORM.—Plate IV.

Synonyms: G. Das Erbsenbein. *Fr.* Le pisiforme. *L.* Pisiforme, subrotundum, rotundum, orbiculare.

Known by its being pea-like and having a single facet.

It is placed on the front of the cuneiform, and has a strong muscle inserted into it (*extensor carpi ulnaris*), another rising from it (*abductor minimi digiti*), and the anterior annular ligament is connected with it.

A well-marked bone is rather flattened from side to side, and the lower portion overhangs the facet rather more than the upper, and runs downwards towards the unciform with which it is connected. That side of the bone (outer) which is towards the middle of the palm is grooved more than the other (inner). The facet occupying its posterior surface is continued on to the upper border of the bone, and the overhanging bone is grooved on the outer side close to the facet.

Determination.—Hold with articular facet away from you, first noticing carefully into which surface it is most continued, placing this surface upwards, and the larger overhanging part of the bone downwards: the rounded surface, not grooved, looks towards the inner side of the hand—*i.e.*, towards the side to which the hand belongs.

TRAPEZIUM.—Plate IV. and Figs. 15, 16.

Synonyms: *G.* Das Trapezbein. *Fr.* Le trapèze. *L.* Os multangulum majus, rhomboides.

Known by its saddle-shaped lower articular surface for the thumb, by a well-marked ridge and a deep groove, both running vertically, on the anterior or palmar surface, for the tendon of the flexor carpi radialis.

It is the outermost of the second row. The *upper surface* is rather internal, and is smooth, concave for the scaphoid, continuous with the inner surface. *Lower* saddle-shaped, smooth for metacarpal bone of thumb. *Dorsal* rough, non-articular. *Palmar* rough, narrow, with well-marked vertical ridge for anterior annular ligament and some of the muscles of the thumb (*abductor* and *flexor brevis pollicis*); on the inner or ulnar side of this ridge is a deep vertical groove for the tendon of *flexor carpi radialis*. *Outer* or radial side rough for ligaments. *Inner* continuous with upper, has a large concave facet for trapezoid above, and a small oblong one below for the projecting edge of the second metacarpal bone.

Determination.—Hold with ridged (palmar) surface facing you, the ridge being vertical, and the saddle-shaped surface downwards and outwards: the groove will be on the inner or ulnar side of the ridge—*i.e.*, will point to the side to which the hand belongs.

TRAPEZOID.—Plate IV. and Fig. 15.

Synonyms: *G.* Das Trapezoidbein. *Fr.* Le trapézoïde. *L.* Os multangulum minus, trapezium minus pyramidale.

Is known by its small size and irregular trapezoid shape, having four sides faceted.

It is the smallest of the second row, and is placed like a wedge between the trapezium and magnum, the base of the wedge being towards the dorsum. *Upper surface* four-sided, usually narrow, with margins nearly parallel, rather concave from before backwards, articulates with scaphoid. *Lower surface* concave from before backwards, convex from side to side, fits into hollow at base of second metacarpal. *Dorsal* large, rough, non-articular, its lower and inner angle projecting considerably towards third metacarpal. *Palmar* rough, small, and gives attachment usually to part of the *flexor brevis pollicis M.*; this surface is prolonged outwards and backwards below, between the outer and lower surfaces of the bone. *Outer* four-sided, articular, continuous with the upper surface, sometimes entirely separated from the lower by a prolongation of the palmar non-articular surface. *Inner* longer than outer, concave from before backwards.

Determination.—Hold with large non-articular (dorsal) surface away from you, and with prolongation of anterior surface downwards and to one side, the narrow, sharply-defined, oblong facet being uppermost: the base or dorsal portion will project towards the inner side—*i.e.*, towards the side to which the hand belongs.

OS MAGNUM.—Plate IV. and Fig. 15.

Synonyms: *G.* Das Kopfbein. *Fr.* Le grand os. *L.* Os capitatum.

Known by its large size, pyramidal shape, with rounded head and slightly constricted neck.

It is the largest bone of the carpus, and its head fits into the arch formed by the first row. *Upper surface*, forms only part of the head, and is rounded, smooth, articulating with semilunar. *Lower* rather triangular, smooth, divided by two ridges from before backwards, the outer part being for the second, the middle and larger for the third, and the inner and smallest for the fourth metacarpal bone. *Dorsal* rough, broad, projecting at its inner and lower angle. *Palmar* rough, with a prominent tubercle: this surface gives attachment to the *flexor brevis pollicis M. Outer* smooth above, and continuous with the upper sur face, articulates with the socket of the scaphoid; below this is a rough and constricted neck; and below this again is a small facet for the trapezoid, continuous with the lower surface. *Inner* presents a hollow articular surface above for the unciform, and a smaller flattened surface below and behind for the same bone, but sometimes distinct from the upper facet.

Determination.—Hold with the head upwards and narrow non-articular surface directly facing you; the dorsal portion projects below towards the inner side —*i.e.*, towards the side to which the hand belongs.

UNCIFORM.—Plate IV. and Fig. 15.

Synonyms: *G.* Das Hakenbein. *Fr.* L'os crochu, unciforme. *L.* Os hamatum, cuneiforme.

Known by its hooked process.

It is placed at the inner end of the second row, is wedge-shaped with its base downwards, and its unciform process springs from the lower part of its front or palmar surface. *Upper surface* is the apex of the wedge and articulates with the semilunar. *Lower surface* is the base, and is smooth for articulation with the fourth and fifth metacarpals, a slight ridge dividing this surface into two facets. *Dorsal* broad, irregularly triangular, non-articular. *Palmar* triangular, with unciform process standing forwards from its lower and inner part; the process is concave towards the middle of the hand and gives attachment to the anterior annular ligament, *flexor brevis*, and *opponens minimi digiti Ms.* *Outer* is smooth and articular above and behind, and a second facet is often seen below, sometimes continuous with the former, both being for the os magnum. *Inner* extends from the apex to the lower surface, and is articular and sinuous for the cuneiform bone in all but a narrow rough edge below, which separates the articular portion from the lower surface.

Determination.—Hold with unciform process towards you, and springing from near the lower edge of the surface facing you, the broad part of the wedge being below, and apex of the wedge upwards; the convex side of the unciform process will point towards the inner or ulnar side—*i.e.*, to the side to which the hand belongs.

METACARPUS.—Plate IV.

Synonyms: *G.* Die Mittelhand. *Fr.* Le metacarpe.

Situation.—The metacarpus is placed between the wrist and fingers, and is composed of five bones which are named from their positions—that belonging to the thumb being called the first; that to the little finger the fifth. It must be noticed that the first is in reality a phalanx (page 62).

Shape.—Each metacarpal bone is a long bone; the four inner are closely connected together, and form by the manner in which their carpal ends are fitted together a transverse arch, which is a continuation of that of the carpus. The outer, or thumb's metacarpal, is a more separated and moveable bone than the others: when seen from the dorsum the bases of the metacarpal bones together form an uneven line, the irregularity of which is chiefly caused by the projection of the adjoining angles of the 2nd and 3rd between the trapezoid and os magnum.

Common characters.—**Head** is placed towards the fingers, rounded from before backwards, flattened from side to side for articulation with base of phalanx, broader in front than behind, so that lateral movement of the fingers cannot take place when they are flexed. On its sides are well-marked depressions for strong ligaments uniting adjacent bones; behind and above each of these depressions is a tubercle for the lateral ligament of the joint. The head is formed from a separate point of ossification and in young bones can be readily separated by violence.

Shaft prismatic, slightly curved, so as to be con-

cave towards the palm; has three surfaces, one dorsal and two lateral. *Dorsal* is flat, triangular, with base of triangle running on to the head of the bone, covered by tendons of the *extensor Ms.*; the apex of the triangle is continuous with a median ridge separating two depressions towards the base of the bone for the *dorsal interossei Ms. Lateral* slightly hollowed for interossei; the *anterior edge* of the bone forms a rather prominent rounded ridge, and a foramen for a nutrient artery pierces it, running towards the head except in the first bone.

Base, or carpal end, is irregularly cuboid. Owing to or rather as a cause of the transverse arch of the metacarpus the bases of the inner four are broader on the dorsum than in the palm. Their basal *surfaces* are smooth for articulation with the carpal bones; the *lateral* rough for ligaments over the greater part, but also faceted in places where they come in contact with adjacent bones; *palmar* and *dorsal* surfaces are rough for muscles and ligaments.

Special characters. **1st Metacarpal.**—Broader and shorter than the others, more moveable, capable of being brought towards middle of palm, in appearance resembles an enlarged phalanx—a resemblance supported by the fact that the foramen for the nutrient artery runs towards the base, and the base (not the head) is developed as a separate epiphysis. *Head* broader from side to side than from before backwards, has two small tubercles in front, over which move the **sesamoid bones,** two little bony masses in the *flexor brevis pollicis. Shaft* broad, flat with no triangular marking on the dorsum. *Base* has a saddle-shaped articular surface for the trapezium, the projecting lip of the palmar edge being well marked

and situated rather nearer the inner or ulnar side; the outer or radial part of the base projects as a tubercle for the *extensor ossi metacarpi pollicis M.*

Determination.—Hold the bone with the palmar surface facing you: the tubercle on the base is on the outer side, and is the safest guide, though, in a well-marked bone, the projecting lip will be inclined towards the ulnar or inner side, and will point to the side to which the hand belongs.

2nd Metacarpal.—The longest, known by its large base, with two nearly equal projections, making a zigzag outline as seen from behind. This and the three following bones answer the general description given for metacarpal bones, but the base has certain peculiar features. *Base* large, projects more towards the inner or little finger side. *Dorsal surface* rough for ligaments, and towards the outer side is a rough tubercle for the *extensor carpi radialis longior:* the edge of this surface shows the zigzag outline of the base. *Palmar surface* rough for *flexor carpi radialis M.* The *articular surfaces at the base* are four:—1. Largest, at the extreme end of the base, rather four-sided, hollow from side to side for the trapezoid. 2. On the inner side of the base large and sometimes double for the third metacarpal. 3. Small on the outer side for the trapezium. 4. Smallest on the edge between 1 and 2 for the os magnum. The bone is wedged in between three of the carpals.

Determination.—Hold with the palmar surface facing you, the base upwards; the more prominent angle at the base projects towards the third metacarpal, or towards the inner side—*i.e.*, to the side to which the hand belongs; the tubercle on the dorsum is on the thumb side.

3rd Metacarpal.—Known by the very projecting angle on the radial side of the base, and by its triangular basal facet. On the dorsum is seen a tubercle upon the projecting angle for the insertion of the *extensor carpi radialis brevior*. The lateral facet on the radial side is single or double for the second metacarpal bone, and is continuous with the triangular basal facet for the os magnum; the lateral facet on the ulnar side is either single or double for the fourth metacarpal. This bone articulates with one carpal bone only.

Determination.—Hold with the palmar surface facing you, and the base upwards; the projecting angle of the base points towards the second metacarpal or to the outer side, and therefore away from the side to which the hand belongs.

4th Metacarpal.—Known by its clubbed base, without special projections, and with lateral facets on each side, by which it must be distinguished from the fifth. Its *basal* facet is double, one four-sided for the unciform bone, and continuous with the lateral facet of the inner side for the fifth metacarpal, which also articulates with the unciform; the other small facet is posterior and external, for the os magnum. The *lateral facet* on the radial side is double and quite distinct from the other facets. The bone articulates with two carpal bones.

Determination.—Hold with the palmar surface facing you, and the base upwards; the lateral facet which is continuous with that on the base is for the little finger's metacarpal bone—*i.e.*, points to the side to which the hand belongs.

5th Metacarpal.—Known by its having only one lateral facet, and by its resemblance otherwise to the metacarpal bones. The inner or ulnar side of the

base has a projecting *tuberosity* for the *extensor carpi ulnaris M.*, and the front surface is rough for a slip from the *flexor carpi ulnaris M.* The *basal* facet is sinuous, like the under surface of the unciform with which it articulates; the *lateral* facet for the fourth metacarpal is continuous with the basal facet. The bone articulates with one carpal.

Determination.—Hold with the palmar surface facing you, and the base upwards; the tuberosity and rough non-articular surface will be on the inner side—*i.e.*, will point to the side to which the hand belongs.

Therefore we find that the inner or ulnar side of the base is known in the

1st metacarpal by having no tubercle, and by the projecting point of the anterior margin being generally nearer to it.

2nd metacarpal by having a large lateral facet, and by the more prominent angle of the base being on this side.

3rd metacarpal by being less prominent than the outer.

4th metacarpal by the lateral facet being continuous with the basal.

5th metacarpal by having no lateral facet.

Whereas the radial side is known in the case of the

1st metacarpal by a tubercle for the *extensor ossis metacarpi pollicis M.*

2nd metacarpal by a tubercle for the *extensor carpi radialis.*

3rd metacarpal by a tubercle for the extensor carpi radialis brevior.

4th metacarpal by a lateral facet being double and not continuous with the basal.

5th metacarpal by having a lateral facet.

PHALANGES.

The three small bones forming each finger are called phalanges. The thumb is usually said to have two only, but this error results from the first being called a metacarpal bone.

A phalanx is a miniature long bone, and consists of a base or metacarpal end, a shaft, and a head or distal end. The *base* presents an oval, concave, articular surface, divided in the second and third rows by a median ridge which runs from before backwards. The *shaft* is flat on its palmar surface, with well-marked edges for the attachment of the sheath (theca) of the flexor tendons, convex on its dorsal surface. The *head* is smaller than the base, and presents a pulley-like articular surface, convex from before backwards, and extending more at the palmar than on the dorsal surface, so as to allow of greater freedom in flexing than in extending the fingers, grooved for the ridge on the base of the adjacent bone. The head of the ungual phalanx is non-articular, rough, convex from side to side, flattened from before backwards.

1st, or proximal or metacarpal phalanx* has the basal articular surface smooth, oval, and concave.

2nd, or middle phalanx, has its basal articular facet divided longitudinally by a median ridge, and possesses an articular head.

3rd, or distal, or ungual phalanx, has its head flattened, and non-articular. Its palmar surface is rough for the pad of the finger-tip. On its dorsal or smooth surface the nail lies.

The **fingers,** or **digits,** are called in order from the

* Synonym : *G.* Die Grundphalange.

radial side, 1st, 2nd, &c., or thumb, index, middle, ring, and little fingers. Of these the thumb is the most moveable, the middle longest and most constant among vertebrate animals. In the horse, the three phalanges of the middle digit constitute the great pastern, little pastern, and coffin-bone, while the hoo represents the nail.

Development of the Bones of the Hand.—The carpus is cartilaginous at birth, but subsequently each carpal bone is ossified from a single nucleus.

The outer four metacarpals are developed from two centres apiece—one for the shaft, and one for the distal end of the bone.

The phalanges and so-called metacarpal of thumb are developed each from two centres—one for the shaft, and one for the base or proximal end of the bone.

The carpal nuclei appear in the following order: os magnum, 1st year; unciform, 1st, or 2nd year; cuneiform, 3rd year; trapezium and semilunar, in 5th year; scaphoid, 8th year; trapezoid, 8th or 9th year; pisiform, 12th year.

The metacarpal nuclei appear in the shafts, in 8th or 9th week of fœtal life; the epiphyses from the 3rd to 5th year, uniting about the 20th year.

Those for the phalanges are a little later than those for the metacarpal bones.

Mechanism of the Hand.—Can we wonder that an organ so useful, so active, so expressive as the hand, presents evidences of most perfect mechanical construction? Taken as a whole, we have an organ which can express by its motions or positions either fear or confidence, pain or pleasure, caution, silence, scorn or anger. To express these and a thousand

other feelings, various mechanical contrivances are brought into work, and to examine these we may look at each part—carpus, metacarpus, and phalanges—first, and then at their action together.

With regard to the *carpus*, it has already been noticed that it consists of a number of bones closely bound together, forming a semi-solid mass of curious shape. In this mass we find three arches formed—one with its convexity towards the radius, one with its hollow towards the palm, and a third, which is double, between the two rows of which the carpus is composed. Remembering that each arch is constructed of bones capable of gliding slightly over

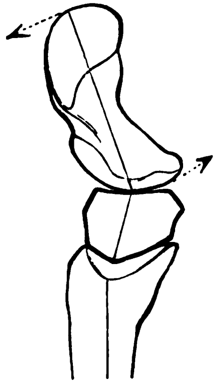
Fig. 15.

Diagrammatic view of Carpus, showing manner in which force is diffused. *sc.* Scaphoid. *sl.* Semilunar. *c.* Cuneiform. *tr.* Trapezium. *td.* Trapezoid. *m.* Os magnum. *u.* Unciform. 1, 2, 3, 4, 5. Metacarpal bones.

one another, we see that the violence to which this part is constantly exposed is broken by a wonderful natural mechanism. Each bone is elastic, is coated with elastic cartilage, and slides upon its neighbour as far as its surrounding ligaments will allow. But if we look further we shall have still further cause

for wonder. Each separate bone, apparently so unimportant, is definitely arranged so as to protect the wrist from injury by breaking or distributing the force applied, as it usually is, along the axis of the metacarpal bones. It will be seen by the accompanying diagram (Fig. 15), from Mr. Ward's excellent Manual, that violence applied along any one of the metacarpal bones is distributed rapidly in the carpus. It will be seen moreover that the carpus may be divided into two lateral portions, corresponding to the arrangement followed in the tarsus. Now, in striking with the fist, the middle metacarpal carries the shock of the blow, and this is spread by the head of the os magnum separating the scaphoid and cuneiform, and tending to force itself into the palm, but becoming wedged in between its neighbours. But in most work in which the hand is employed pacifically, in pressing or striking with a tool grasped, in falling on the palm, &c., force is transmitted through the outermost two metacarpals. In the diagram this force is seen to be distributed from the second by the oblique position of the scaphoid, but this diagram does not show, what is seen in a side view (Fig. 16)—that the scaphoid is obliquely placed both with regard to the trapezium and trapezoid, and that by this means force is again broken.

Fig. 16.



Side view of thumb.
Trapezium and Scaphoid.

In the unfixed state of the carpus, a good deal of

movement of flexion occurs between the upper and lower rows, the os magnum acting as the lever, and throwing forwards or backwards its lower extremity.

It must be borne in mind that other advantages are gained by the curves of the carpus, that important structures are protected in the palm, that leverage is given for tendons, and prominences are afforded for the attachment of muscles.

Looking at the *metacarpus*, its constituent bones spread from the carpus, or more correctly, converge towards the carpus, where the middle ones are firmly fixed, only the first, fourth, and fifth allowing of much movement. Each bone is comparatively free at its distal end, the first being entirely so; and each of the outer four bones is strengthened by a spine on its palmar aspect. As a result of the freedom of the distal ends, we find the hand capable of being spread out flat or arched, according to whether pressure is used or the hand is grasping an implement.

The *phalanges* are only capable of simple flexion and extension between themselves, extreme extension being checked by a strong anterior ligament.

Now, if we regard the joints formed by these parts—carpus, metacarpus, and phalanges—with one another, and with the bones of the forearm, we see that in the *wrist-joint* provision is made for all movements except rotation. The convex carpus lies in the larger and flatter radio-ulnar articulation, separated from the ulnar by the triangular ligament, and flexion, extension, abduction, and adduction are freely allowed. The upper articular surface of both rows of carpal bones being prolonged further on the dorsum, a large amount of extension occurs. The ulna being further removed from the carpus, adduc-

tion is especially provided for; and here we notice, as in the elbow and in other joints, the greater facility for the limbs being brought towards the body which it has to minister to and protect.

If we look at the bony skeleton alone, it would appear that this joint is poorly protected against dislocation, considering the violence to which it is constantly subjected; but as a fact, this joint is one of the least liable to dislocation. In the opinion of an eminent surgeon "it is doubtful whether this ever occurs, except in the diseased wrist,"* and this is accounted for by the strong protection which is given by the numerous tendons surrounding the joint.

At the *carpo-metacarpal* articulations it has already been noticed that the second and third metacarpal bones are almost fixed, but that the fourth and fifth allow of flexion so as to render the palm hollow, while the first, which it must be remembered is really a phalanx, allows of great freedom of movement both from before backwards, and from side to side, owing to the saddle-like surface at its base. "To the diversified motion of this joint, the great mobility of the thumb, and its power of opposition to the fingers (an action characteristic of the hand) are, in great measure, to be ascribed."

At the *metacarpo-phalangeal* articulations all kinds of movement, even including rotation to a slight degree, are allowed of, and hereby the great usefulness of the fingers as prehensile organs is insured.

In the mechanism then of the hand we have a subject worthy of our deepest admiration. By its means we labour, teach, feed ourselves, and can

* Le Gros Clark, "Outlines of Surgery," p. 95.

express the various thoughts and emotions of the mind. It is equally adapted for using force or working with the utmost delicacy; and, far surpassing our feeble inventions, Nature here produces, as she always does, the most numerous and diversified results by the simplest possible means.

Upper Extremity as a whole.—The mechanism of the several parts and joints has been discussed in connexion with each bone, but it may not be uninteresting to look at the limb as a whole, and point out certain

Fig. 17.

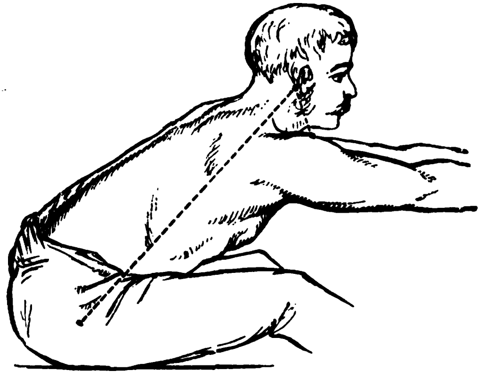
Sitting at rest. Showing tip of shoulder behind the line from mastoid process to hip.

mechanical peculiarities which have not been hitherto observed.

Remembering that the limb is connected with the trunk at the sterno-clavicular articulation alone, and

that at this joint considerable freedom of movement is allowed, it will be seen that the mechanism of the limb in certain actions is peculiarly interesting. A great increase in extent of action is allowed of

Fig. 18.



Forward movement in rowing, showing tip of shoulder far in front of the line from mastoid process to hip.

by an arrangement curiously parallel with that of the sliding seat now adopted in rowing—that of a shifting fulcrum. In all laborious work in which the upper limb is involved this is brought into operation. In pulling, for instance, upon a rope or an oar, the arms and shoulders are thrown forwards to the utmost, the weight of the body drags the object backward, then at the same time as the arms are bent the shoulders are thrown backwards, so as to bring the fulcrum as far backwards as possible. This is effected by means of the dorsal muscles (*trapezius, rhomboidei, and latissimus*) which can be seen standing out as firm fleshy mounds on the back of the athlete.

In pushing anything from close to the body the reverse takes place. The fulcrum is at first placed posteriorly, the shoulders being thrown back, then

Fig. 19.

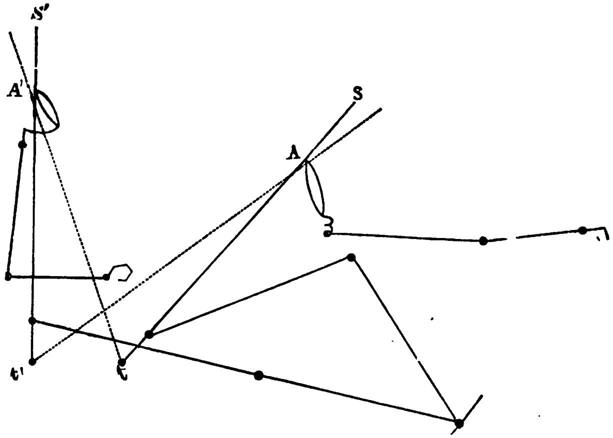


Diagram to show sliding-seat action at the shoulders. In the forward position the arm is thrown forward so that the shoulder is about three to four inches in front of the spinal line S A t. In the backward position the same point is about one to two inches behind the same line S' A' t', the whole movement occurring at the sterno-clavicular articulation. The sliding of the tuberosities of the ischia backwards in this movement is equal to about eight inches (t to t'). The dotted lines show the degree of forward or backward movement of the body which would be necessary to gain the same range of arm-movement, if the tuberosities were fixed and no sliding were used.

the body being thrown forward the shoulders are brought forward and reach their utmost in this direction as the arms are stretched out to their limit.

Similarly the shoulders are carried upwards or downwards as the arms are applied to pull up or down any weights.

As the arms are carried from the side we have

already noticed that the shoulder-joint is concerned only until the horizontal line is reached; after this the upward movement involves the movement of the clavicle and scapula and the rotation of the humerus.

The upper limb is however constructed to resist the effect of pressure or shock, as well as to serve for the purpose of leverage. For this end we find various contrivances which may, however, be examined as curves, obliquities, and elastic media. These either give elasticity or break the force of concussion by diverting it or diffusing it. When a blow is struck with the fist out "from the shoulder," it requires very little experience to tell that the force which is carried in the blow along the axis of the limb is considerable enough to endanger the safety of the limb if no provision were made for its protection.

To this end every long bone is curved or doubly curved, each bone is strengthened by ribs or else by spiral ridges; each has in its interior a wonderful architecture of fibres interlacing in parabolic curves, whose sum total represents the perfection of strength with lightness.

If these modifying influences be traced carefully they will be found to vary according to the position of the limb, but we may profitably examine them when the arm is placed away from the body at right angles to it, so as to include the longest possible chain of bones—in such a position as when in falling on the side the arm is stretched out to save one.

If the hand be open much of the force of the fall will be broken by the obliquity of the metacarpal bones, and usually by the bending of the elbow, but if the knuckles receive the full weight and the arm be fully stretched out, then we notice the shock must

be lessened first by curves of the metacarpal bones themselves, then by the curious oblique articulations already noticed in the carpus, and by the spreading of the bones of the upper row from the projecting os magnum being forced into the hollow of the first row. From the carpus force is transmitted to the radius, which is curved and ribbed, but as it does not articulate with the humerus when the arm is stretched out, the violence of the shock of a blow is carried to the ulna by means of the ligaments; and hence we see the necessity for the fibres of the interosseous membrane being directed from the radius downwards and inwards to the ulna. The ulna in its turn is curved and ribbed, and its upper end cup-shaped to fit against the humerus; and here must be noticed the curious radiating internal structure of the ulna at this extremity, whereby still greater strength, elasticity, and lightness are insured.* The humerus is doubly curved and strengthened by a spiral moulding; its internal structure is peculiarly adapted to withstand the

Fig. 20.

Diagram showing how force is broken when applied through the length of the upper limb.

* Another curious mechanical arrangement here has been pointed out by Professor Humphry. The surfaces of the ulna which come in contact with the Radius are differently placed above and below; that below overhangs the Radius, so that it receives part of the force transmitted through the wrist. The articular surface above rather underhangs that of the Radius.

violence of blows along its axis; and at the shoulder-joint the force would be greatly broken and diffused by the obliquity of the contact even in the position of the limb we have selected as that showing the most direct line from hand to sternum. In tracing the shock onwards we find it much more broken by the manner in which the chain of bones continues; from the glenoid cavity the acromion stretches at the top of an arched flying buttress—the edge of the spine—and at an angle with this acromion is fixed the clavicle, fended sometimes by a washer, the inter-articular fibro-cartilage. All these obliquities must considerably break the force, already so much diminished, and then comes the elasticity of the clavicle itself, due to its double curve, a power sufficient to enable it to spring two feet from a wall when struck. The arrangement at the sterno-clavicular articulation and the ligamentous bands tying the clavicle down to the rib and sternum are peculiarly strong, and would assist in protecting the bone, though their special use is in preventing displacement upwards. Such then is a rough outline of the way in which Nature protects her creatures, and provides them with the means of using an amount of force through a limb, which does not react hurtfully upon the materials used or on the being using them.

INNOMINATE BONE.—Plate V.

Synonyms: *E.* Hip-bone. *G.* Das Hüftbein, Ungenanntebein. *Fr.* L'os coxal, des iles. *L.* Os coxæ, pelvis.

Situation.—The innominate bone is an irregularly shaped bone forming part of the pelvis. It is placed between the sacrum and the femur.

Shape.—It resembles nothing in particular, and is therefore called innominate.

Parts.—In the child it consists of three separate parts, the **Ilium,*** the **Ischium,**† and the **Pubes,**‡ which unite about the age of puberty, but indications of the separate portions often remain throughout life. The three join in the cup-shaped cavity, or acetabulum, seen about the middle of the outer surface of the bone. The Ilium is the flattened portion which supports the flanks (ilia): the Ischium is the strong portion which occupies the buttocks (ischia); the Pubes is the front portion and supports the external organs of generation, and takes its name from this part being covered with hair. A large hole (obturator or thyroid foramen) remains between the Ischium and Pubes. In the natural position the Ilium is uppermost, while the Ischium and Pubes spread from the acetabulum and unite again below the obturator foramen and form the lower edge of the bone, which is placed nearly horizontally when the body is erect.

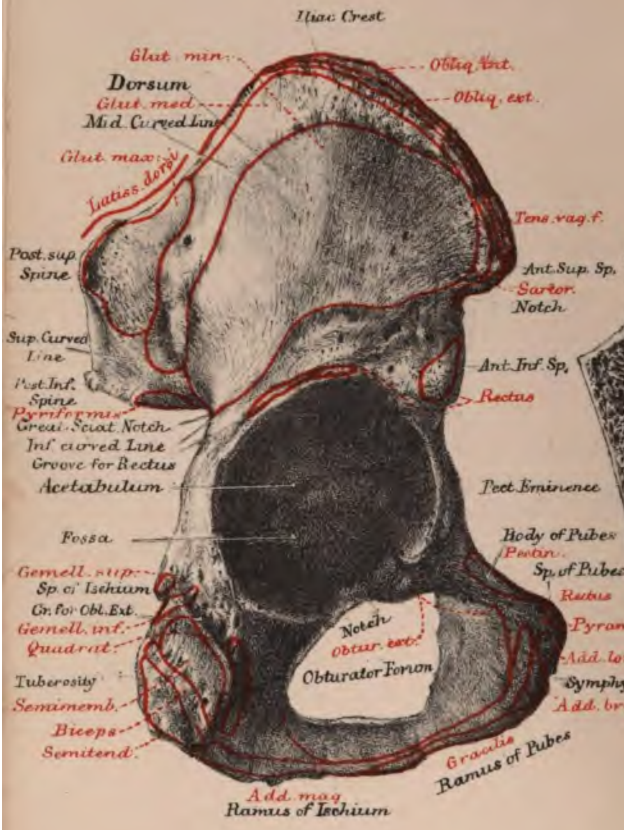
It is best to consider the bone as a whole and not

* Synonyms: *E.* Haunch-bone. *G.* Das Darmbein. *Fr.* L'ilion.

† Synonyms: *E.* Seat-bone. *G.* Das Sitzbein. *Fr.* L'ischion.

‡ Synonyms: *E.* Share-bone. *G.* Das Schambein, Schoosbein. *Fr.* L'os pubien.

OUTER SURFACE



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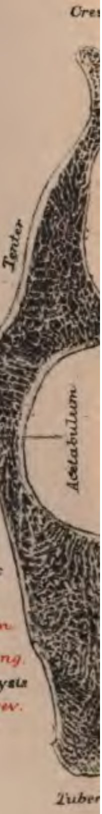
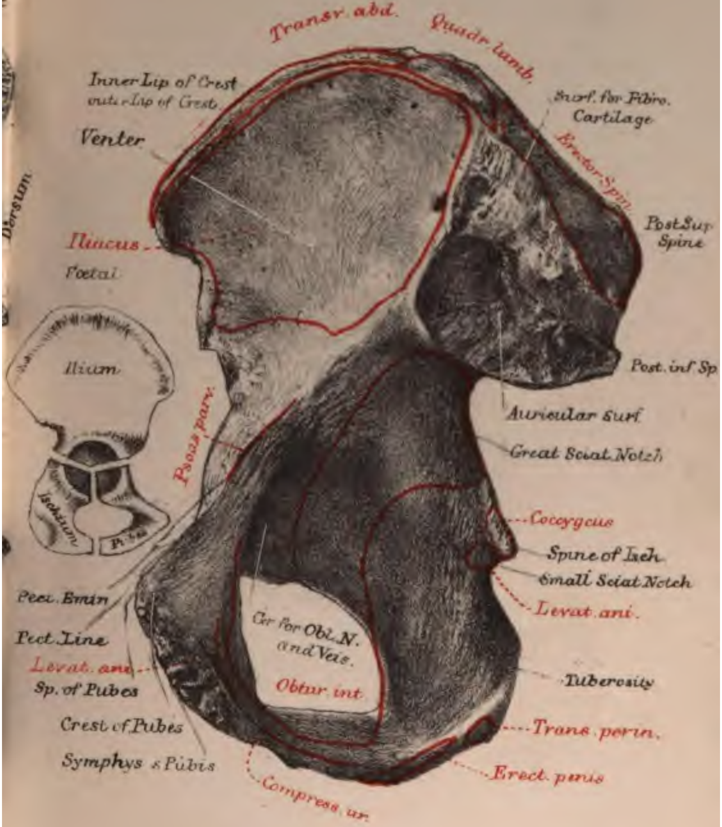


ION

INNER SURFACE



to examine each part separately, since the distinction between them is not evident in the majority of bones.

Examine four borders—upper, lower, anterior, and posterior, and two surfaces—inner or pelvic, and outer.

Upper border is the **crest of the ilium**, thick, convex from before backwards, doubly curved like an italic *ʃ* when viewed from above, has two lips or edges for the attachment of abdominal muscles—the outer for *external oblique and latissimus dorsi Ms.*, and for the *fascia lumborum*, the inner for *transversalis* and *quadratus Ms.*, the intervening portion for the *internal oblique* and *erector spinæ Ms.* The crest ends in front in a thick angle, the **anterior superior spine** of the Iilum, for a strong ligamentous structure (*Poupart's ligament*), which runs to the angle of the Pubes, and for two muscles, the *sartorius* and *tensor vaginæ femoris.* It ends behind in a still thicker angle, the **posterior superior spine** of the Ilium, for the attachment of the *sciatic ligaments.*

Anterior border, extending from the anterior superior spine to the angle of the pubes. Immediately below the anterior superior spine is a **notch**, from which rises part of the *sartorius M.*, and through which passes the *external cutaneous nerve.* The projection below this is the **anterior inferior spine** for the origin of the *rectus M.* Next is seen a groove for the *iliacus M.* overlying the acetabulum. The border now becomes broad, and is occupied by an eminence, the **pectineal eminence**, from the front of which runs a ridge of bone joining the edge of the acetabulum with a rough tubercle upon the angle of the pubes, called the **spine of the pubes**, for the inner attachment of *Poupart's ligament.* This ridge forms the anterior limit to a triangular smooth surface (for the *Pectineus M.*),

and acts as a buttress for the acetabulum. A rather rough ridge now runs backwards and inwards from the spine to the inner and back limit of the angle of the pubes, and is called the **crest of the pubes**; it gives attachment to the *rectus, pyramidalis, internal oblique*, and *transversalis Ms.*

Lower border, from angle of Pubes to angle of Ischium, thick at each end, narrow in the middle, convex from before backwards. Towards the front end it is broad and rough for a strong fibro-cartilaginous structure, which unites the two pubic bones; this union, or **symphysis pubis,** is about an inch and a half in depth, and between its two halves a small synovial space exists at the upper and back part. Below the symphysis the two pubic bones diverge and form an arch, the **arch of the pubes,** which is larger in females than in males. It gives attachment to the *triangular ligament, gracilis*, and *erector penis Ms.*, and the *crus penis*. About half-way along this lower border an indentation is often visible, which marks the original separation of pubes and ischium. The border now widens, and ends in the **tuberosity of the ischium,** which belongs, however, to the posterior border.

Posterior border, from posterior superior spine of Ilium to Tuberosity of Ischium; a very irregular ridge, with three notches. Immediately below posterior superior spine of Ilium is a small notch, separating it from the **posterior inferior spine** of Ilium; to all these parts are attached the upper ends of the *sciatic ligaments.* Next comes a very deep notch, the **great sciatic notch,** converted into a foramen naturally by the *great* and *lesser sciatic ligaments*, and giving passage to the *pyriformis M., gluteal, sciatic*, and *internal pudic*

vessels and *nerves*, and the *nerve to the obturator internus.* The lower extremity of the notch is formed by a sharp projection, the **spine of the ischium,** for the attachment of the *lesser sciatic ligament* (to the tip), the *levator ani* and *coccygeus Ms.* (to the inner surface), and the *gemellus superior M.* (to the outer surface). Below this again is the **lesser sciatic notch** converted into a foramen by the sciatic ligaments, and giving passage to the *obturator internus tendon,* and to the *pudic nerve* and *vessels,* and the *nerve to the obturator internus,* which are re-entering the pelvis by this means. The border ends in the **tuberosity of the ischium,** a broad rough surface upon which the weight of the body rests in sitting, covered, however, by the thick pad of the *gluteus maximus M.,* and protected by a bursa; to its outer lip are attached the *quadratus* and *adductor magnus Ms.;* to its inner the *gemellus inferior* and *transversus perinæi Ms.,* and the *great sciatic ligament;* and to the intervening rough surface the *semi-membranosus, biceps,* and *semi-tendinosus Ms.* of the back of the thigh.

Inner surface divided into two by a well-marked ridge, the **ilio-pectineal line,** part of which has been already seen in the examination of the anterior border; this line forms part of the *brim of the pelvis* and separates the upper and anterior portion (for the false pelvis) from the lower and back portion (for the true pelvis), while a triangular rough surface is left between the great sciatic notch and the crest of the ilium, which is in neither true nor false pelvis, but is for the **sacro-iliac** joint, or **synchondrosis.** The ilio-pectineal line runs from the front angle of this rough surface to the spine of the pubes.

(a) *Upper portion,* or **venter of ilium,** is smooth,

slightly concave, and flattened for the support of the abdominal viscera, and for the origin of a muscle (the *iliacus*).

(b) *Lower portion* is altogether in the true pelvis, is smooth behind and above for the *obturator internus M.*, is perforated by the **obturator foramen,** a large foramen which is closed in by a membrane, the *obturator membrane,* in the recent state, and is usually more triangular in the female than in the male (though this difference is by no means constant). Above the foramen the surface is grooved for the *obturator vessels and nerve* which perforate the membrane; the **body of the pubes** lies in front of the foramen, while the **ramus of the pubes** is that portion which lies below the foramen and joins the **ramus of the ischium.** On the pelvic surface of the ischium below the spine is a groove which is continued into the lesser sciatic notch, and the inner lip of the tuberosity and ramus of the ischium is prominent for the great sciatic ligament and its process (*the falciform*).

(c) *Sacro-iliac portion* is peculiarly rough behind for strong sacro-iliac ligaments, but in front shows a curious ear-shaped surface, **auricular surface,** for contact with the sacrum.

Outer surface divided into two parts by the acetabulum; the upper and back portion composed of ilium, and part of the body of ischium, runs backwards and inwards, the lower and front portion composed of pubes and ischium runs forwards and inwards.

(a) *Upper and back portion* sinuously convex, marked by three not always distinct lines called superior, middle, and inferior curved lines. The **superior curved line** runs from the crest a short distance

above the posterior superior spine, and ends behind the middle of the great sciatic notch; it marks the line of separation between the *gluteus maximus* behind, and *medius* in front. The **middle curved line** starts from a short distance above the anterior superior spine, and curves backwards to end about the middle of the great sciatic notch, generally close to the superior curved line; it marks the space between the *gluteus medius M.* behind, and *minimus* in front.

The **inferior curved line** is generally indistinct; when well marked it can be traced from the notch below the anterior superior spine curving backwards nearly parallel with the edge of the acetabulum, to end on the lower side of the great sciatic notch; it shows the limit of attachment of the gluteus minimus. Above the acetabulum is a curved groove running backwards from the anterior inferior spine for the reflected tendon of the *rectus femoris M.*

(b) *Lower and front portion* consists of the greater part of the pubes and ischium. Continuing from acetabulum downwards and forwards is the **body of the pubes,** to end at the symphysis. Notice here the smooth triangular surface in front of the Pectineal line for the origin of the *pectineus M.;* this overhangs a groove in the upper and front side of the obturator foramen for the passage of the *obturator vessels and nerves* into the thigh. From the symphysis the pubic bone passes outwards and backwards as the **ramus of the pubes,** below the obturator foramen to meet the **ramus of the ischium,** and a line sometimes marks their junction. These bones give attachment to the *adductor Ms.* and *obturator externus.* Below and behind the acetabulum is a groove sepa-

rating it from the Tuberosity of the ischium; it is for the tendon of the *obturator ext. M.* The **obturator foramen** is the large oval, or in females sometimes triangular, hole, bounded by pubes and ischium, occupied naturally by strong membrane, which is imperfect above, opposite to the groove in the body of the pubes, and which gives attachment to muscles on both surfaces.

(c) **Acetabulum** is a cup-shaped cavity, imperfect below, occupied in the natural state by the head of the femur, deepened by a thick ligament (*cotyloid ligament*) which is attached all round its projecting edge. It is formed by the junction of the three bones: the ilium occupying rather more than two-fifths, the ischium rather less than two-fifths, and the pubes the remaining fifth. Its margin is incomplete below where the **notch** is left, through which pass vessels and nerves into the inside of the joint. The notch is nearly an inch in width, and is continuous with a shallow groove running to the bottom of the socket; the edges of the notch give attachment to the *ligamentum teres*, and the bottom of the groove is filled with a soft synovial pad. It seems, therefore, that a large part of the acetabulum does not come in contact with the head of the femur, but it must be noticed that there is no position of the limb in which the head of the femur would naturally and exclusively press against the unprotected portion of the acetabulum. The bottom of the acetabulum is often so thin as to transmit light, and it is easy to understand how disease in the joint may extend through the thin bone into the pelvis.

Articulations.—With three bones—viz., the sacrum, by the sacro-iliac synchondrosis, the femur by the ace-

tabulum, and the opposite innominate bone by the pubic symphysis.

Development.—From six to eight centres. The six constant centres are found in (*a*) the ilium, first seen in about the eighth week of fœtal life; (*b*), in ischium in the third month; (*c*), pubes in the fifth month; (*d*), as a Y-shaped piece along the line of junction of these parts in the acetabulum, seen about the thirteenth year; (*e*), along the crest of the ilium; (*f*), in the tuberosity of the ischium. The two latter appear about puberty, as do also the less constant centres in (*g*) symphysis pubis, and (*h*) anterior inferior spine. The acetabulum is all bony about the seventeenth year; the rami unite earlier, generally about the eighth year; the epiphyses unite as usual about the twenty-fifth year.

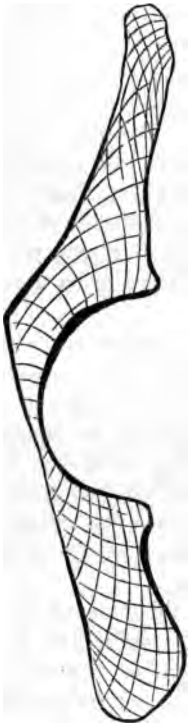
It sometimes happens that the opposite pubic bones do not unite at the symphysis, and this deformity is generally, but not always, attended by a curious and troublesome defect, due to an imperfect closure of the abdominal walls. The bladder may in such a case be "extroverted" or the genital organs fissured. The obturator foramen is sometimes incompletely formed by the non-union of the pubes and ischium below.

Mechanism.—We have to look at this bone alone in this place, and afterwards we must consider it in connexion with the sacrum, in examining the pelvis. We notice here the thickened crest, not only useful for the attachment of muscles, but also protective to the pelvis and its contents, exposed as this part is to pressure at times. Its peculiar curved outline forming an italic *ʃ* has been already referred to, and indicates the combination of elasticity and

strength which are necessary in a bone liable tc pressure.

Next to be noticed is the strong prismatic thicken-

Fig. 21.



Innominate bone.—Vertical section from anterior superior spine to tuberosity of ischium, showing plan of construction.

Fig. 22.

Innominate bone.—Horizontal section along brim of pelvis.

ing which extends from the sacro-iliac synchondrosis to the top of the acetabulum, continued forwards as the body of the pubes. This forms a curve which in the articulated pelvis is completed into a ring by the promontory of the sacrum and the opposite innominate bone; and upon this ring, combining as it does elasticity with strength, the spinal column with the weight of the body is supported above, and concussions through the thigh-bones are transmitted to it below on the sides. It must be remembered that the innominate bone is placed obliquely, and the pelvic ring also obliquely, so that force is further broken by this means—an important mechanical arrangement for the protection of the body and its delicate nervous centres from injury by concussion.

Another architectural groining or thickened line of bone is to be noticed extending vertically from the anterior superior spine of the ilium to the tuberosity of the ischium.

If a section be made through the bone along this line (Fig. 21), the structure indicates a provision for support along it, and it is in this line that force is applied while in the sitting posture. We see divergent curves starting from the opposite walls, and interlacing so as to produce by their junction gothic arches. The curves are definitely related to the great focus of pressure in the acetabulum, and start perpendicularly to its surface.

If we examine a section now (Fig. 22) made along the thickened mass which forms the ring of the pelvis, a beautiful mechanical structure is seen. Here again are curves, still divergent and interlacing, still springing in great part perpendicularly from the surface of the acetabulum, and still indicating the most

exquisite provision for strength, and elasticity with lightness.

We may see by the accompanying diagram (Fig. 23) the manner in which this bone acts as a lever of the first order.

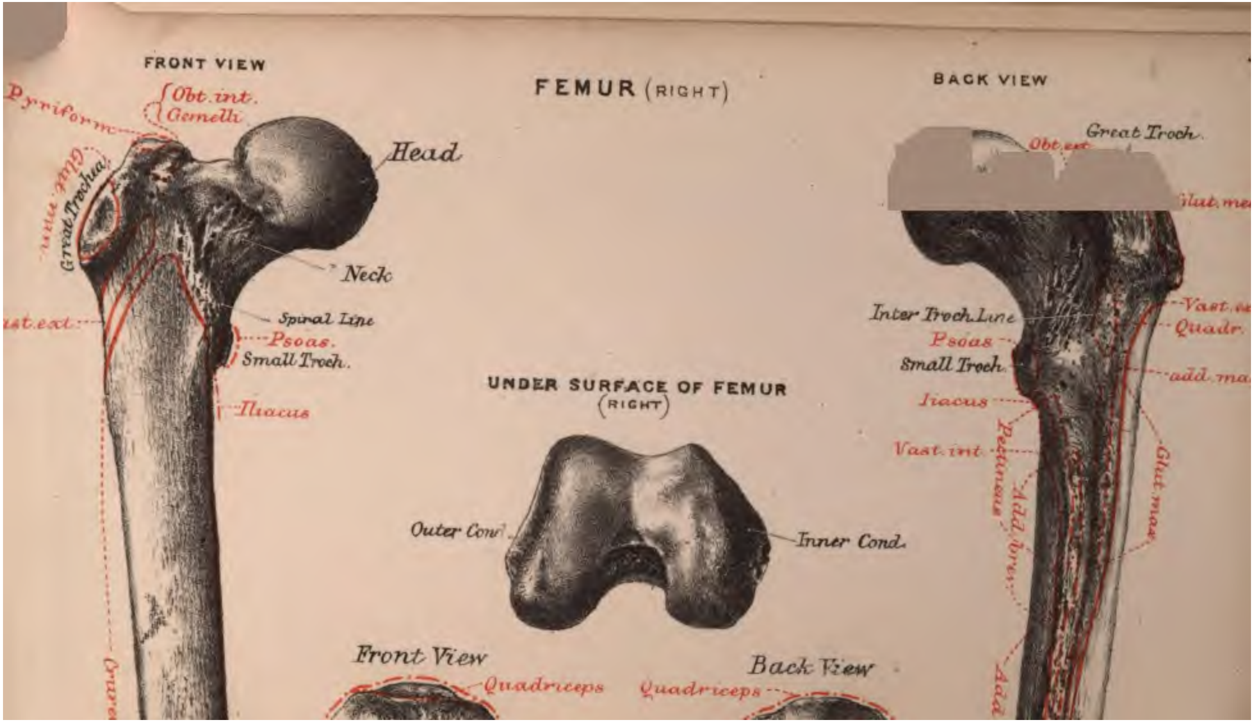
Means of distinguishing right from left.—Hold as if in your own body, with the ilium upwards, the pubes pointing forwards, downwards, and inwards, and the concavity inwards; the acetabulum will be on the outer side—*i.e.*, will point to the side to which the bone belongs.

Fig. 23.

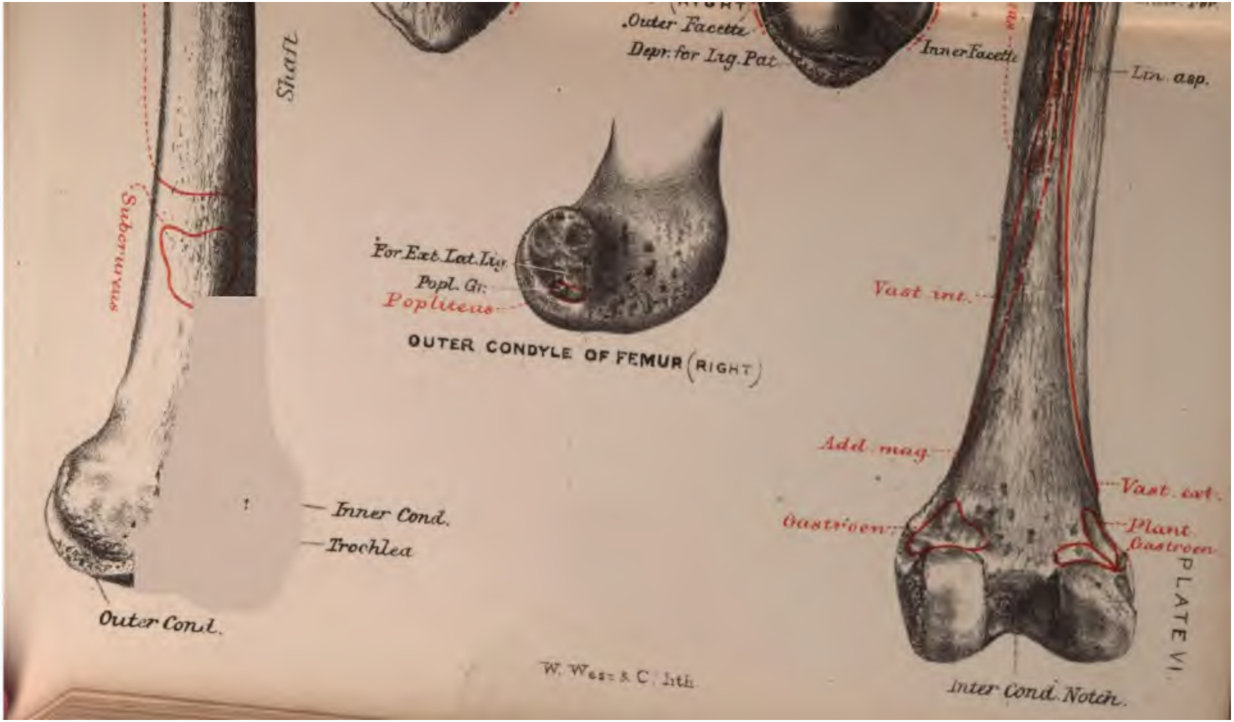
Showing lever formed by spine and pelvis.

Points of importance:—

1. Compounded of three bones, each entering into the formation of the acetabulum.
2. Peculiar sacro-iliac surface.
3. Composition, arrangement, and development of the acetabulum.
4. Obliquity of the bone.
5. Number and importance of spinous processes.
6. Tuberosity of the ischium, forming the sitting process and the end of the lever for the action of the hamstrings.
7. The thyroid foramen and the sciatic notches, constructed so as to give lightness and means for the yielding of parts in childbirth.
8. Mechanical structure and uses.



FEMUR (RIGHT)
FRONT VIEW
Pyriform
Obt. int.
Gemelli
Glut. min.
Great Trochia
Head
Neck
Spiral Line
Psoas.
Small Troch.
Iliacus
UNDER SURFACE OF FEMUR (RIGHT)
Outer Cond.
Inner Cond.
Front View
Quadriceps
Back View
Quadriceps
BACK VIEW
Great Troch.
Inter Troch. Line
Psoas
Small Troch.
Iliacus
Vast. int.
Pectineus
Add. brev.
Glut. max.
Quadr.



OUTER CONDYLE OF FEMUR (RIGHT)

FEMUR.—Plate VI.

Synonyms : *E.* Thigh-bone. *G.* Das Schenkelbein. *F.* L'os de la cuisse, fémur. *L.* Os femoris, cruris.

Situation.—The femur is the bone of the thigh, and extends from the pelvis above to the tibia below.

Shape.—It is the largest bone of the body. It is a long bone with a globular head placed on a rather long neck, which runs obliquely from the upper part of the shaft. The bone is enlarged below, where it forms a broad massive base, the two lateral masses of which, or condyles, are separated behind by a deep notch.

Parts.—For the purpose of description we may divide the bone into—1, an upper end, including the Head, Neck, and two Tuberosities; 2, shaft; 3, lower end, including the two condyles with their curious articulating surfaces.

1. **Upper end.** The head is placed obliquely on the neck; the neck runs to the two trochanters, the great trochanter being the large mass above, the small trochanter being the pyramidal mass situated behind and below, and joined to the former behind by a well-marked ridge, the inter-trochanteric line.

Head is smooth, globular, forms rather more than a hemisphere, looks upwards, inwards, and a little forwards; its margin is sinuous, the curves showing the limits of rotation inwards and outwards, and of adduction. The smooth articular surface extends about equally in front and behind, but more above than below. Rather below the centre is an irregular depression for the femoral attachment of the *liga-*

mentum teres, which connects it with the acetabulum.

Neck, directed from the trochanters upwards, inwards, and forwards, is flattened from before backwards, constricted and cylindrical towards the head, while near the trochanters it is much broader from above downwards than from before backwards; longer below than above, and behind than in front; limited by the inter-trochanteric line behind, and by a rough line in front (the spiral line), by the great Trochanter above, and by the lesser Trochanter below; smooth behind, for the play of muscles, especially the *obturator externus*, the capsule of the joint intervening; rough in front, marked by numerous foramina for vessels. Its posterior surface is overhung by the Great Trochanter, under which is a well-marked depression—the Trochanteric or Digital fossa—for the insertion of the *obturator externus M.* Neárly the whole of the neck is enclosed in the Capsule of the hip-joint, which extends rather further upon it in front than behind. From the position and shape of the neck this part of the femur is very liable to fracture, particularly in old people, where the bones are brittle and where the neck is more at right angles. Such a fracture is rare in the adult, owing to the mechanical arrangement of the cancellous tissue of the neck being more perfectly developed, and to the neck being placed advantageously for strength, and to the bones being more tenacious. In the old, union rarely takes place after fracture of the neck, since the parts are insufficiently supplied with blood; in fact it is only where the fracture is impacted, as when the head and neck are driven tightly into the trochanter, that bony union is likely to follow.

Great Trochanter is the large four-sided mass which forms really the summit of the shaft. It projects above the neck, overhanging the Trochanteric fossa. It is broad in front, narrow behind, the upper border projecting backwards; it is limited below by a horizontal line, the level of which is nearly halfway between the tip of the great trochanter and the lesser trochanter. It has three borders—upper, lower, and posterior; and three surfaces—anterior, outer, and inner.

Upper border, horizontal, projecting posteriorly over the neck; it is facetted for *obturator internus* and *pyriformis Ms.* *Lower border* marked by a horizontal line best seen towards the front, while posteriorly is a small, rough prominence, situated at the upper end of a vertical line on the shaft; the horizontal line indicates the limit of attachment of *Vastus externus* below and *Gluteus medius* and *minimus Ms.* above. *Posterior border* is sharp and is continued into the inter-trochanteric line.

Anterior surface somewhat triangular, its outer half being occupied by an oblong flat impression for the *Gluteus minimus M.;* along its inner edge is a *tubercle* which marks the beginning of the spiral line. *Outer surface* large, four-sided, marked by an oblique rough line (the **oblique line**) extending from the tip behind to lower angle in front; this is for the *Gluteus medius. Inner surface* overhangs the neck and is deeply pitted by a fossa, the **digital or trochanteric fossa** for the *obturator externus M.*

Lesser Trochanter pyramidal, projects behind and below neck on inner side, and receives at its extremity the insertion of the *Psoas M.* Its *upper border* is continuous with the inter-trochanteric line; its *lower*

border continues as the line leading to the linea aspera; *posterior surface* smooth and flat; *anterior surface* smooth and hollowed, continuous with that of the neck, is triangular and gives attachment to the *Iliacus M.* The **inter-trochanteric line** is the prominent ridge uniting the two trochanters posteriorly. The **linea quadrati** is a rough vertical line, not always well seen, running on the great trochanter and downwards from it as far as the level of the lesser trochanter; it gives attachment to the *quadratus femoris.* The **line leading from great trochanter to linea aspera** starts from the middle of the lower edge of that mass, and runs vertically downwards to join with a similar line from the lesser trochanter at a point about one-third down the shaft. The **spiral line** starts from the tubercle, on the anterior aspect of the bone, runs downwards and inwards between the neck and shaft, passes about an inch to the inner side of the lesser trochanter and joins the linea aspera; it limits the upper attachment of the *vastus internus* and *crureus M.*

2. **Shaft** prismatic, apparently twisted inwards, curved in its length with convexity forward, giving attachment to a muscle (the *crureus*), on the front and outer surface; it presents three borders (posterior, outer and inner) and three surfaces (anterior, outer and inner).

Posterior border, a single rough ridge in the middle third of the bone and called the **linea aspera.** This line divides above into the two lines leading to the two trochanters and the spiral line; it bifurcates below into the two lines leading to the two condyles, the inner one of which ends in a tubercle for the insertion of the tendon of the *adductor longus M.*, and the smooth space

between the two lines is the **popliteal surface of the femur.** The linea aspera therefore occupies only the middle third of the bone; it has two lips or edges, the inner for the attachment of the *vastus internus* and *adductor longus Ms.*, the outer for the *vastus externus* and short head of *biceps Ms.*, and the intermediate space for the *adductor magnus M.* About the middle is usually a large canal running upwards (thus differing from that in the homologous bone the humerus) for the *nutrient artery*. *Inner border* is smooth and rounded and extends from middle of spiral line to tubercle on inner condyle. *Outer border* ill defined extends from great trochanter to the front of the outer condyle.

Anterior surface smooth, occupied by *crureus* and *subcrureus Ms.* *Inner surfaee* smooth, distinct above, lost below where it runs into the popliteal surface. *Outer surface* also smooth, more distinct below where it forms the outer side of external condyle.

3. **Lower end.** The shaft gradually widens below, and ends in two condyles, which are continuous in front, but separated by a deep notch behind. Of these lateral masses or **condyles** the inner is more massive and apparently extends lower than the outer, but the outer occupies a little more of the front of the bone. The smooth articular surface extends more over the outer condyle in front, but behind it involves both condyles about equally.

Examine first the rough outer and inner non-articular surfaces on the *outer condyle* (compare Figs. 43 and 44); notice that the margin of the articulating surface forms a double curve, that rather above the centre of the posterior curve is a projecting point called the **tuberosity,** for the *external lateral ligament* of the

knee-joint, the rough raised surface behind it being for the origin of one head of a large muscle belonging to the calf (the *Gastrocnemius.*) Below and behind the Tuberosity is a deep groove running upwards and backwards, the **popliteal groove,** occupied by the Tendon of the *Popliteus M.*, which is fixed to the anterior rough end of the groove.

On the *inner condyle* notice again the doubly curved outline of the articular surface, a rough **tuberosity** also situated nearly at the centre of the posterior curvature and also for the attachment of the *lateral ligament* of its side. Above this at the end of the line leading from the linea aspera to the inner condyle (**inner condyloid ridge**) is the **tubercle** for the *adductor magnus M.;* this is sometimes much enlarged and forms a bony process which interferes with the gripping power of the knees; it is therefore to be looked for in examining cavalry recruits. The upper part of the inner condyloid ridge is interrupted by a smooth space near the linea aspera, and it is here that the femoral artery lies in passing from the front of the thigh into the ham. Behind the Tuberosity is a raised flat surface for the inner head of the *Gastrocnemius M.* *Articular surface* large, important, horseshoe-shaped, separated by the intercondyloid notch behind, occupying rather more of the outer condyle in front, convex from before backwards. Looking at the bone behind, the two condyles are seen to be covered by the smooth articular surface; looking at the bone in front the articular surface covers the base of the shaft; looking at it in section the two portions are seen to have their proper curves; and looking carefully at the base of the bone (Fig. 24), certain grooves can be seen separating these surfaces

from one another; two grooves, (1, 1), one on each side, limiting the proper condyle surfaces in front; a groove (2) separating the remainder of the inner condyle from the pulley-like surface (Trochlea) in front.

Proper condyle surfaces parallel with one another extend equally behind, and to an equal distance on the two condyles in front—*i.e.*, to the level of the front limit of the notch. A groove separates the outer condyle surface from the trochlea, and another separates the inner from what may be termed the **oblique portion** of the inner condyle. Each *proper condyle surface* is convex from side to side, but bevelled on the side towards the notch; in some bones this is seen to be due to separate marginal facets. The antero-posterior curve of each surface is nearly a semicircle (Figs. 43 and 44, *a*), and they are of equal size, the common axis running through the centre of each tuberosity opposite the attachment of the two lateral ligaments.

Fig. 24.

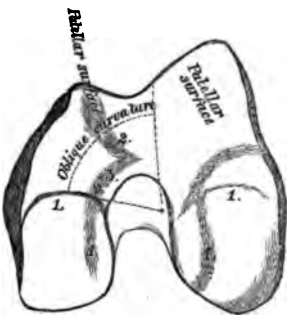


Diagram of under surface of condyles of femur.

Trochlear or *patellar surface* is the anterior part, and extends higher up on the outer side; it is limited behind by two slightly marked grooves, that on the inner side being rather the more anterior, and separating it from the oblique surface of the inner condyle. The Trochlea is deeply grooved from before backwards, and the groove (*Patellar* groove) ends

behind in the inter-condyloid notch; the outer part of this trochlear surface is in nearly the same antero-posterior line as the outer condyle; the inner runs nearly straight forward from the front end of the "oblique surface." These points are important to notice in connexion with the mechanism of the joint.

Oblique surface of the inner condyle is the obliquely curved portion of the articular surface between the inner "patellar" and inner "proper condyle" surfaces; towards the notch a portion is marked off, forming a facet for the articulation of the patella in extreme flexion.

Inter-condyloid notch is deep above, and shows other depressions in it on the overhanging condyles; that on the inner side of the external condyle is for the *anterior crucial*, that against the inner condyle is continued forward to the middle line, and is for the *posterior crucial ligament*.

Why are these peculiar surfaces, facets, and curves found? The condyles are separated by a notch for the lodgment of strong crucial ligaments, the proper condyle surfaces with their semicircular curves are for simple antero-posterior movement, the oblique surface is for the rotation of the tibia in the last act of extension, by which means our toes are naturally turned slightly outwards in the erect posture, and the trochlea is for the play of the patella.

Articulations.—With three bones—Innominate above; tibia and patella below.

Development.—From five centres, one for the shaft, which appears earlier than in any other long bone, except the clavicle, and usually in about the fifth to seventh week of fœtal life; one for the lower end in the ninth month of fœtal life; one for the head about

one year after birth; one for the great trochanter in the fourth year; and one for the lesser trochanter at puberty. The upper epiphyses unite with the shaft about 18–20 years, and the lower a year or two later.

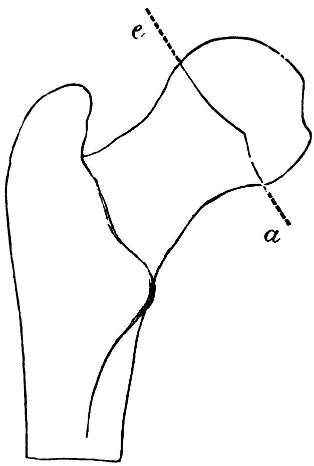
Variations in Form due to Age, &c.—The neck is short, and almost absent in the fœtus; increasing to considerable length and obliquity in the adult; diminishing again to a right angle, and the head at length hardly projecting from the shaft in advanced age. It is more at right angles with the shaft in the female than in the male, and helps to produce the great width which distinguishes the female hips, a width due chiefly to the larger size of the pelvis. According to size, the neck of the femur is rather longer in the female than in the male.

Mechanism.—More has been written probably about the mechanism of this bone than of any other, but more still remains to be pointed out. We may notice in order: 1, the hip-joint; 2, the obliquity of the neck; 3, obliquity of the shaft; 4, obliquity of the lower surface; 5, curves of the bone; 6, internal structure, and leave the consideration of the lower surface until the tibia and patella have been examined.

The hip-joint is a modified ball-and-socket joint, not so perfect, however, as the shoulder, since the movements are more limited, and the head of the femur has a ligament running from the centre of it to the acetabulum. Goodsir describes the mechanism of the hip-joint, not as a ball-and-socket, but as a conical screw joint, the screw being worked up tight in extension, and unscrewed in flexion. We notice with regard to the acetabulum that the greater strength of the bone is situated above and behind in the direction of the greatest pressure, that the socket

is deepened in the natural state by a fibro-cartilaginous rim, that its contact surface is diminished owing to the presence of a shallow fossa in which fat and a synovial pad lie, that the edge is broken by a notch through which vessels enter the joint, and that at the bottom of the fossa the bone is so thin that it is readily perforated; in disease of the hip-joint, this

Fig. 25.



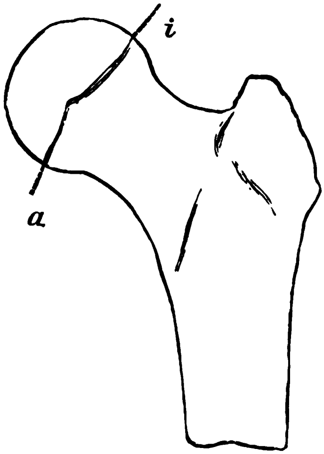
Posterior view of head of femur, showing outline of articular surface.

plate is sometimes eaten through, and as a consequence suppuration may extend from it into the pelvis and even into the bowel.

With regard to the femur we notice the globular head is articulated somewhat obliquely to the acetabulum, and if we look carefully we can notice, what has hitherto escaped the observation of anatomists—

that the outline of the articular surface is not uniform, but arranged in three curved lines (Figs.

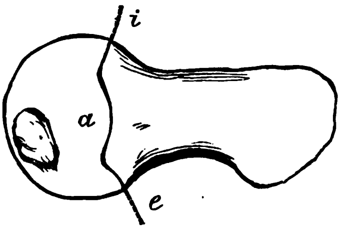
Fig. 26.



Anterior view of head of femur, showing outline of articular surface.

25, 26, 27). One of these is placed below and the other two in front and behind, meeting at the upper-

Fig. 27.



Under view of head of femur, showing outline of articular surface.

most limit. They indicate the limits of adduction, inversion and eversion; when the limb is adducted, the line (*a*) corresponds with the edge of the acetabulum; when inverted, the line (*i*); and when everted the line (*e*) lies along the edge of the socket.

We next notice the large projections or trochanters which stand off at a distance from the joint and afford such powerful leverage for the muscles which are to rotate the thigh.

(2) Before examining the movements at the joint more carefully, we may observe the obliquity and length of the neck. This varies, as has been already stated, according to age and sex, and even in different individuals. In an ordinary adult bone the axis of the neck is placed at an angle of about 130° with that of the shaft, and about at an angle of 115° to the vertical line of the body, the shaft being about 15° from the perpendicular; but it must not be supposed that we have here an angular bone with neck and shaft arranged as coarsely as is seen in the axle and spokes of a cart-wheel (Fig. 28). On the contrary, we see that the *inner edge of shaft and neck together form a distinct curve* which supports the pressure of the acetabulum far more securely than any such rough mechanical contrivance, and yet at the same time provides for them all the advantages in movement which an angular bone would secure to a lever whose one end was fitted into a socket. This curve has been generally overlooked in the greater

Fig. 28.

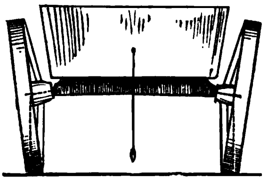


Diagram of arrangement of axle in a cart.

attention which authors have given to the obliquity of the neck. When the body is equally supported on the two thigh bones, the weight is borne by the upper half of the head and carried through a number of curved bony fibres to the curve formed by the inner edge of the shaft and neck (Fig. 30). When the body is supported on one leg the femur is thrown over more obliquely, and now those fibres which spring from nearer the middle of the head carry the weight.

(3) The obliquity of the shaft must also be now noticed, as its main object is to bring the lower supporting surface towards the middle line of the body. It varies according to the distance to which the trochanters have been thrown away from the pelvis, and according to the width of the pelvis itself, and is not a simple obliquity but is curved for greater strength and elasticity.

The movements at the hip-joint are of all kinds—flexion, extension, adduction, abduction, inversion or internal rotation, eversion or external rotation, and circumduction. Of these, that of flexion is the most extensive and important. Now this is effected by the elongation of the neck thrown out to meet the shaft at an angle. By this means the angular motion of the shaft is converted into a rotatory movement at the hip-joint, and thereby the extent of bearing surface in the joint is equalized in the different degrees of flexion, the same amount being in contact when the body is bent forward as when the body is erect. For, as is seen in the accompanying diagram, taken from Mr. Ward's excellent work, the angular motion of a ball-and-socket joint (Fig. 29, A) "throws part of the ball out of the socket, and leaves part of the socket without bearing to rest upon, so that the

weight instead of being distributed equally over the whole surface of the head, is concentrated upon that portion which remains within the cavity." Such would be the case if the femur were constructed so as to meet the acetabulum perpendicularly. In the case of flexion to a right angle one-half the bearing surface would be lost (Fig. 29, B). By the obliquity of the neck this evil is considerably diminished, since the act of flexion of the limb is performed by rotation of the head (Fig. 29, C).

Fig. 29.

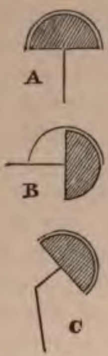


Diagram showing — A, Simple ball and socket, B, Simple ball and socket at right angles. C, Simple ball and socket with oblique neck, as in femoral joint.

The extent of flexion is consequently increased: so far as the bones are concerned it is unlimited, but actually flexion is limited by contact of the thigh with the abdomen, extension by a strong anterior ligament (ilio-femoral). Still the arc through which it can pass is about 145°, whereas if the acetabulum were directed vertically, it would be reduced to 45° or 50°.

By the length of the neck we also gain another advantage—the insertion of the great rotator muscles is removed to a distance from the joint and thereby their power of leverage is increased; moreover, as has been referred to already, the obliquity of the neck being really a curve increases the longitudinal elasticity of the bone.

(4) The obliquity of the lower surface is only apparent, not real, for this surface should lie horizon-

tally. The peculiarity of this surface has been described, but the mechanism of it will be noticed after examining the other bones which enter into the formation of the knee-joint. The length of the inner condyle will vary with the obliquity of the femur, the object being to bring together the Tibiæ so that oscillation of the body need not occur in walking. Notice the unsightly waddling of a very bandy-legged man, and the effect of a failure in the development of the condyles is evident. Usually in such cases the inner condyle is disproportionately small. When the outer condyle is not developed "knock-knees" result, and the ankles are widely separated.

(5) The curves of the bone are of great importance mechanically. They are seen to be (*a*) an antero-posterior one with the convexity forwards, occupying the whole length of the bone—this is often greatly increased in rickets where the bones are soft; behind it is the thick ridge or buttress (linea aspera), the densest part of the whole bone, and this is greatly increased in strength and size when, after the bending of the bones in rickets, nature attempts successfully to remedy the evil; (*b*) the upper part of the shaft is bowed slightly in the opposite direction; (*c*) a lateral curve with its concavity inwards formed by the inner edge of neck and shaft—this is sometimes supplemented by (*d*) an opposite curve towards the lower end seen on the outer side; (*e*) the cylindrical form of the bone. The back of the neck is hollowed out (Fig. 27), and this concavity is of importance in connexion with fracture of this part. The longitudinal curves prevent absolute rigidity, provide great elasticity, and distribute the force of concussion and

superincumbent weight to which this bone is so especially exposed.

(6) If we examine the internal structure of the bone we shall find another example of beautiful mechanical contrivance in nature. As indicated in Fig. 30, the cancellous tissue is very definitely

Fig. 30.

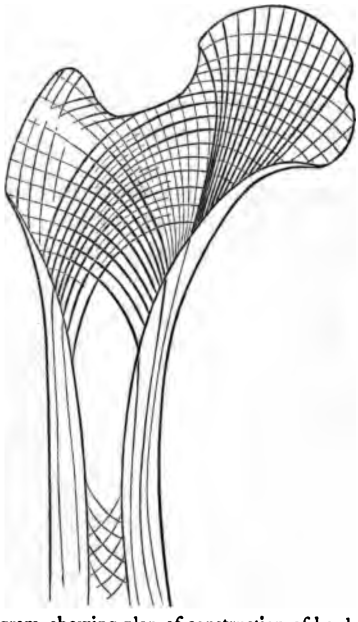
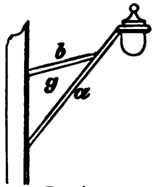


Diagram showing plan of construction of head and neck of femur.

arranged in divergent curves upon the same principle as we have seen in other bones. Certain of these curves can be noticed. One set springs from

the inner wall, spreading into the great trochanter; another set crosses this, interlaces with it, producing a series of gothic arches, and is continued on into the neck and head; a third set, which is a continuation of the first set, springs from the thick lower wall of the neck, spreads into the upper part of the head especially, and ends perpendicularly in the articular surface in the chief part of its extent, but essentially along the lines of greatest pressure in the upper or weight-bearing part of the head. The sum of this arrangement has been roughly and imperfectly likened to a bracket supporting a weight (Fig. 31), but the arrangement in the femur is much more wonderful and effective.

Fig. 31.



Bracket.

If a section be made of the lower end (Fig. 32) we see the bony fibres arranged with distinctness and again in curves, two vertical sets running more or less perpendicularly to the articular surface, one in each lateral half, and another set horizontally.

Fig. 32.

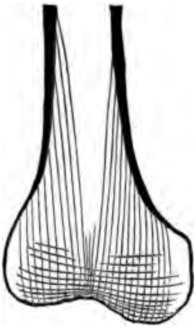


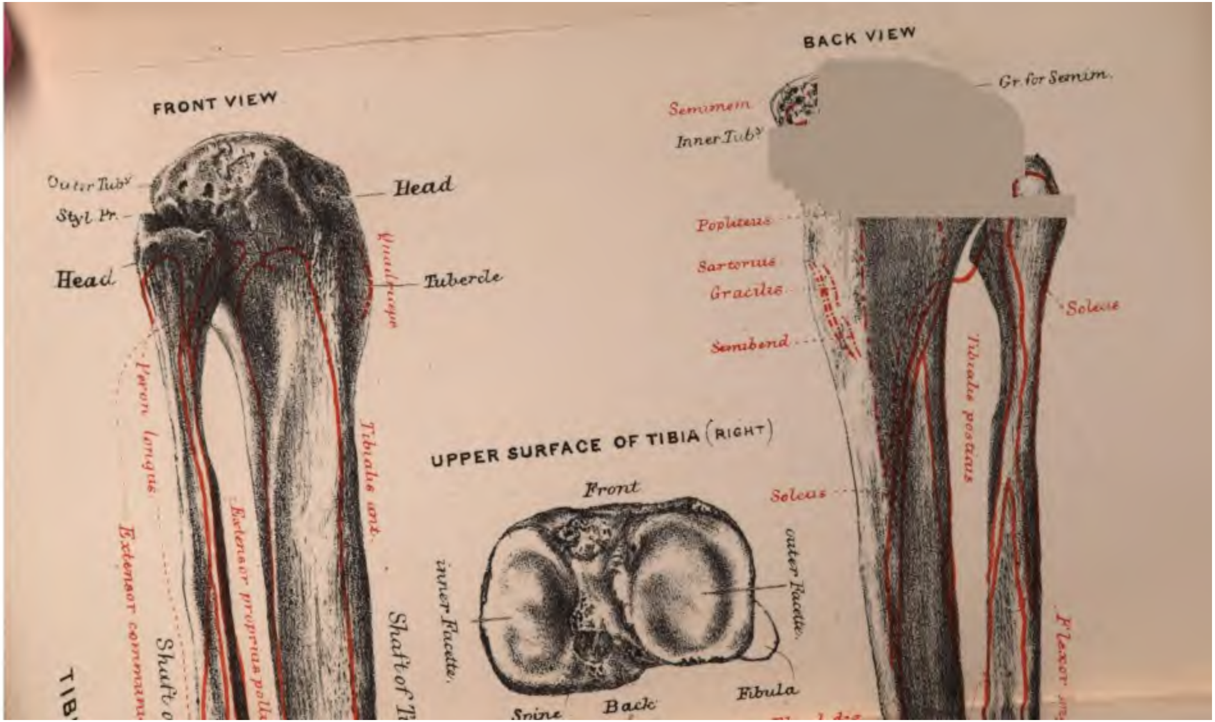
Diagram showing plan of arrangement in lower end of femur, seen in transverse section.

Mode of distinguishing right from left.—Hold in the position it would occupy in your own body, with the head pointing upwards, inwards, and forwards, the trochanter major outwards, and the convex surface of the shaft forwards; the great trochanter and smaller

condyle will be on the outer side—*i.e.*, will point to the side to which the bone belongs.

Points of importance :—

1. Obliquely placed head, neck, and shaft.
2. Great and small trochanters, with ridge joining them behind.
3. The linea aspera and the lines leading from it.
4. The popliteal surface so troublesome in necrosis.
5. Large condyles, with special grooves and prominences.
6. Peculiar articular surfaces.
7. Difference according to age and sex.
8. Mechanism and structure.



FRONT VIEW
Outer Tub.y
Styl. Pr.
Head
Head
Quadriceps
Tuberde
Peron longus
Extensor communi
Extensor proprius poll
Tibialis ant.
Shaft o
Shaft of Ti
TIB
UPPER SURFACE OF TIBIA (RIGHT)
Front
inner Facette.
outer Facette.
Fibula
Spine
Back
BACK VIEW
Gr. for Semim.
Semimem
Inner Tub.y
Popliteus
Sartorius
Gracilis
Semitend
Soleus
Tibialis posticus
Soleus
Flexor

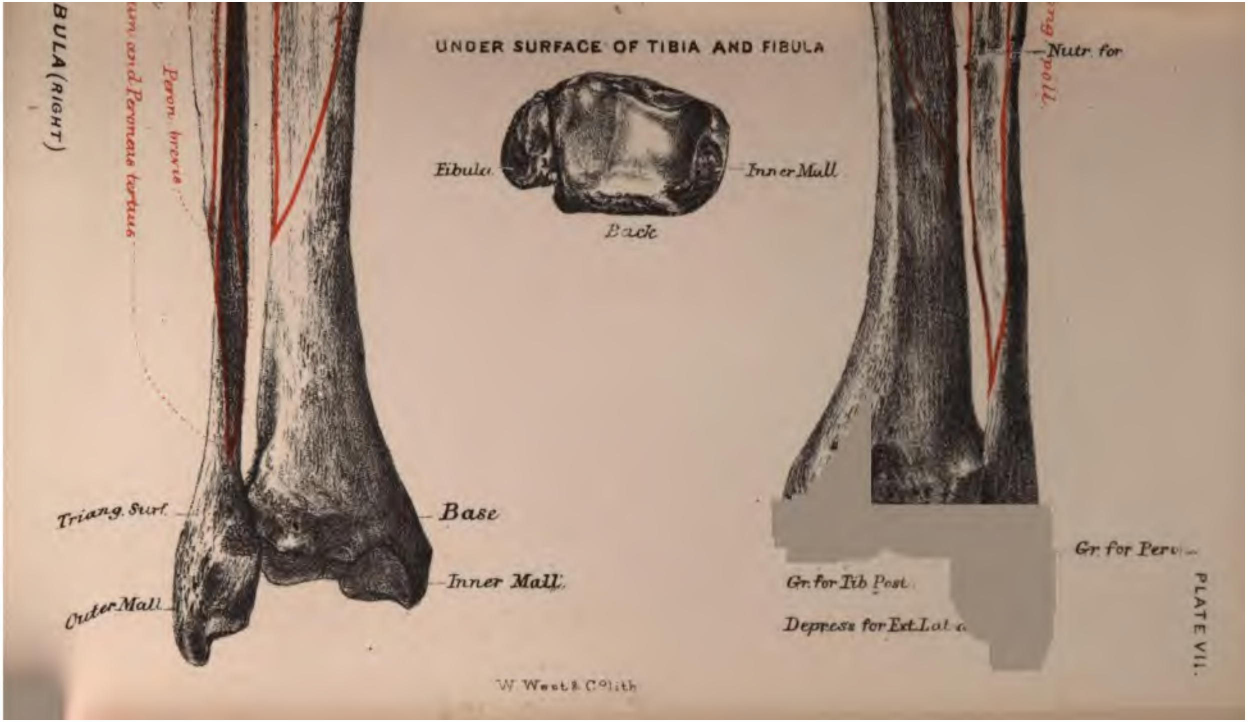


PLATE VII.
UNDER SURFACE OF TIBIA AND FIBULA
Fibula
Inner Mall.
Back
BULA (RIGHT)
Peron. brevis
um and Peroneus tertius
Triang. Surf.
Outer Mall.
Base
Inner Mall.
Nutr. for
ng poll.
Gr. for Tib Post.
Depress for Ext. Lat.
Gr. for Per
W. West & Co. lith.

TIBIA.—Plate VII.

Synonyms : *E.* Shin-bone. *G.* Das Schienbein. *Fr.* Le tibia. *L.* Focile majus, canna major.

Situation.—Extending between the femur and tarsus, and forming the main bone of the leg; it is supported on the outer side by the splint-bone, or Fibula.

Shape.—A long bone, prismatic in form, considerably enlarged above, as the head, to support the condyles of the femur. Its shaft is apparently twisted, and has a sharp anterior edge and a smooth inner surface, which is merely covered by skin, and forms the shin; its lower end is enlarged for articulation with the astragalus, and its inner angle project downwards, as the inner malleolus or ankle.

Parts.—For purposes of description it is divided into—(1) Upper extremity or head, presenting two lateral masses or tuberosities. (2) A shaft. (3) Lower extremity, with projecting internal malleolus.

1. **Upper extremity** large, pyramidal, with base above, broader from side to side than from before backwards, consisting of two lateral masses or *tuberosities,* which are continuous in front, but separated above by a prominent tubercle, the *spine,* and behind by a notch, the *popliteal notch.* The inner tuberosity is rather larger than the outer.

Examine its surfaces, upper, two lateral, anterior and posterior.

Upper surface horizontal, presenting two slightly concave articular surfaces, the outer being somewhat circular, the inner more oval; each is bevelled towards the edge, where it is covered in the natural

state by the semilunar cartilage, while the femur comes into actual contact only with the central part of each; they are separated behind by the **popliteal notch,** in which is attached the *posterior* or *internal crucial ligament;* separated in the middle by a pyramidal process, the **spinous process,** which has two projecting edges for the ends of the semilunar cartilages; separated in front by a rough non-articular surface, on which lies a synovial pad (*infra-patellar*) and a *transverse ligament,* uniting the two semilunar cartilages.

Lateral surfaces rough and vertical above, forming a thick rim, smooth below and continuous with the shaft. The outer tuberosity presents a small articular facet behind and below for the Fibula; the inner tuberosity has a well marked horizontal groove on its upper or vertical part, and this groove for the *semimembranosus* tendon is best seen behind. The extreme upper edge of each tuberosity is sharp, and gives attachment to the coronary ligament which binds down the Semilunar cartilages to the Tibia. Over the inner side the internal lateral ligament of the knee-joint is spread.

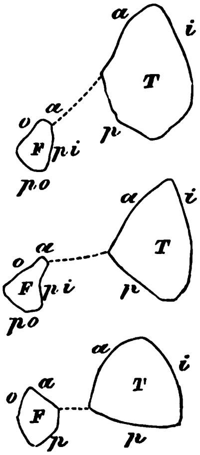
Anterior surface rough, triangular, with base above and apex below, where a prominent **tubercle** is seen; into this tubercle the tendon of the *quadriceps extensor M.* (*ligamentum patellæ*) is inserted, and a bursa exists between the tendon of the upper part of the tubercle where the bone is smooth.

Posterior surface includes the back of each condyle, and presents the *popliteal notch* already referred to, a flattened rim, and a triangular smooth space below (the popliteal surface of the Tibia). Notice the groove on the back of the inner tuberosity, the articular facet

for the fibula on the back of the outer tuberosity, and above this a small oblique groove for the tendon of the popliteus.

2. **Shaft** prismatic, with sharp edge pointing forwards, and smooth, flat, or slightly convex surface inwards, thinnest at the junction of the middle and lower thirds (where fracture commonly occurs), curved with concavity towards the fibula (and this curve is greatly increased when the fibula is defective), apparently twisted inwards below.

Fig. 33.



Section of tibia and fibula in upper third, middle, and lower third. *T*. Tibia. *F*. Fibula. Three surfaces are shown in the horizontal section of the tibia, (*a*) anterior, (*i*) inner, (*p*) posterior, and should be traced in their changes as the section is made on the different levels. In the fibula, (*a*) anterior, (*o*) outer, (*po*) posterior and outer, (*p i*) posterior and inner, (*p*) posterior (combined.) These should also be compared on the different levels.

It presents three borders—anterior, posterior, and outer; and three surfaces—inner, outer, and posterior (Fig. 33, T).

Anterior border extends from tubercle to the front of inner malleolus, is very sharp in the middle, and runs inwards below; to it is attached the deep fascia of the leg. *Posterior border* from below inner tuberosity to behind inner malleolus, rounded, not distinct. *Outer border* from front of facet for fibula on outer tuberosity to a hollow articular facet for the fibula on the outer side of the base, is sharp in the middle two-thirds, bifurcates below, gives attachment to the *interosseous membrane:* notice that the line of this border

state by the semilunar cartilage, while the femur comes into actual contact only with the central part of each; they are separated behind by the **popliteal notch,** in which is attached the *posterior* or *internal crucial ligament;* separated in the middle by a pyramidal process, the **spinous process,** which has two projecting edges for the ends of the semilunar cartilages; separated in front by a rough non-articular surface, on which lies a synovial pad (*infra-patellar*) and a *transverse ligament,* uniting the two semilunar cartilages.

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Posterior surface includes the back of each condyle, and presents the *popliteal notch* already referred to, a flattened rim, and a triangular smooth space below (the popliteal surface of the Tibia). Notice the groove on the back of the inner tuberosity, the articular facet

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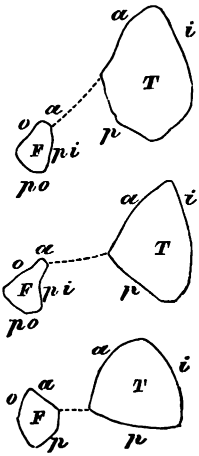
Fig. 33.



Section of tibia and fibula in upper third, middle, and lower third. *T*. Tibia. *F*. Fibula. Three surfaces are shown in the horizontal section of the tibia, (*a*) anterior, (*i*) inner, (*p*) posterior, and should be traced in their changes as the section is made on the different levels. In the fibula, (*a*) anterior, (*o*) outer, (*po*) posterior and outer, (*p i*) posterior and inner, (*p*) posterior (combined.) These should also be compared on the different levels.

2. **Shaft** prismatic, with sharp edge pointing forwards, and smooth, flat, or slightly convex surface inwards, thinnest at the junction of the middle and lower thirds (where fracture commonly occurs), curved with concavity towards the fibula (and this curve is greatly increased when the fibula is defective), apparently twisted inwards below.

It presents three borders—anterior, posterior, and outer; and three surfaces—inner, outer, and posterior (Fig. 33, T).

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(*interosseous line*) is the most anterior and prominent of the lines on the outer side of the tibia.

Inner surface smooth, subcutaneous, forms the shin: there is sometimes a rough oblique line running from near the tubercle downwards and backwards, for the insertion of muscles (*sartorius, gracilis,* and *semitendinosus*). *Outer surface* grooved in its upper two-thirds for the *tibialis anticus M.*, smooth below and coming forwards and covered by the tendons of the *tibialis anticus and extensors* of the toes. *Posterior surface* rather convex from side to side, marked above by an **oblique,** or **popliteal,** or **soleal line,** which runs from the fibular facet downwards and inwards to near the middle of the bone, and gives attachment to the *soleus M.*; near the middle of this line is generally a large foramen for the *nutrient artery,* which runs downwards; the surface below this is divided by a vertical line which runs from the middle of the oblique line to join the outer border, at the junction of the middle and lower thirds; this line separates the *flexor longus digitorum* behind, from the *tibialis posticus* in front.

3. **Lower extremity** thick, four-sided, gradually enlarging as it is traced towards its free surface, distinguished by its projecting inner angle or malleolus.

Examine four sides and the base.

Anterior surface smooth, with horizontal groove near the lower edge, for the *anterior tarsal ligament. Inner surface* smooth, continued on to the projecting **internal malleolus** which is subcutaneous. *Posterior surface* deeply grooved behind the malleolus for a tendon (*tibialis posticus*), slightly grooved in a vertical direction near the outer or fibular margin by another tendon (*flexor longus pollicis*), and grooved horizontally near the free edge for the *posterior tarsal ligaments.*

Outer surface triangular, rough above for strong ligamentous fibres connecting tibia with fibula. Sometimes smooth below for articulation with fibula.

Base or *lower surface* chiefly smooth and articular for contact with the astragalus, but the apex of the malleolus is depressed and rough for the *internal lateral ligament:* the articular surface consists of a horizontal portion and a vertical, the latter lining the malleolus; the horizontal is four-sided, broader in front than behind, concave from before backwards, but marked by a median ridge which makes the surface slightly convex from side to side; this ridge corresponds with a groove on the upper surface of the astragalus; the vertical portion on the malleolus is triangular, small, and articulates with the inner side of the astragalus.

Articulations.—With three bones—femur above, astragalus below, and fibula both above and below.

Development.—Usually from three centres—one for the shaft, appearing in the sixth or seventh week; one for the head, appearing at birth; one for the lower end, in the second year. In this bone, as in other long bones, the lower epiphysis, though last to appear, is the first to unite with the shaft (about the eighteenth year), the upper joining about the twentieth or the twenty-second year. Occasionally there are separate epiphyses in the tubercle, and in the inner malleolus.

Mechanism.—We observe with regard to the tibia, that it has to support the weight of the body entirely, and hence is constructed mainly for strength. We notice that each end is pyramidal, the upper pyramid being inverted. Each of these is porous, while the intervening column is composed of a dense hard shell, and is prismatic in shape. The bone is curved for

greater elasticity, and is moulded in a spiral form, which also adds to its power of resistance. The curve is seen at the junction of the middle and lower thirds, and it is here that the bone bends in rickets, and when the tie-rod or fibula is deficient, it is here that the tibia gives way. Diseases also, such as nodes and necrosis, more often attack this than any other part of the bone.

The enlarged ends serve a definite purpose—that of affording broad surfaces of contact for the femur and tarsus.

Fig. 34.

Tibia.—Vertical section of upper end from side to side.

Fig. 35.

Tibia.—Arrangement seen in anterior-posterior section.

Internal Structure.—Fig. 34 represents a vertical section from side to side through the head of the bone, and is drawn diagrammatically. The principle of construction appears to be—1, a set of nearly vertical fibres in each lateral mass curving

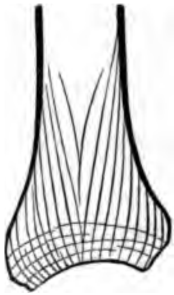
slightly with their concavities towards the middle line; 2, a set of fibres crossing these nearly at right angles, being parallel with the articular surfaces and arranged near them; 3, a set springing from the shaft on each side, and ending upon the rising sides of the spine; these by their interlacement form well-marked arches, which are continued for some distance down the shaft.

A different arrangement is seen when the section is carried from before backwards in the middle line (Fig. 35). The arches spring from opposite sides as a series of increasingly divergent curves, of which

Fig. 36.

Tibia, lower end.—Section including malleolus.

Fig. 37.



Tibia, lower end.—Vertical section from before backwards.

those passing from the front are, on the whole, the best marked, and end behind the spine. Of the other fibres springing from the posterior wall, those are best marked which run upwards to support the pressure of the femur.

Looking now at the lower end (Fig. 36) we find the arrangement nearly the same in whatever direction the section be made. The fibrous columns are

state by the semilunar cartilage, while the femur comes into actual contact only with the central part of each; they are separated behind by the **popliteal notch,** in which is attached the *posterior* or *internal crucial ligament;* separated in the middle by a pyramidal process, the **spinous process,** which has two projecting edges for the ends of the semilunar cartilages; separated in front by a rough non-articular surface, on which lies a synovial pad (*infra-patellar*) and a *transverse ligament,* uniting the two semilunar cartilages.

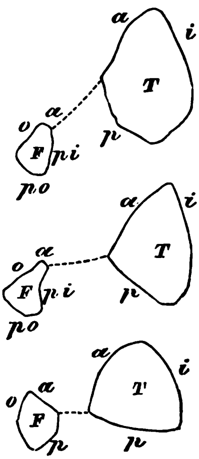
Lateral surfaces rough and vertical above, forming a thick rim, smooth below and continuous with the shaft. The outer tuberosity presents a small articular facet behind and below for the Fibula; the inner tuberosity has a well marked horizontal groove on its upper or vertical part, and this groove for the *semimembranosus* tendon is best seen behind. The extreme upper edge of each tuberosity is sharp, and gives attachment to the coronary ligament which binds down the Semilunar cartilages to the Tibia. Over the inner side the internal lateral ligament of the knee-joint is spread.

Anterior surface rough, triangular, with base above and apex below, where a prominent **tubercle** is seen; into this tubercle the tendon of the *quadriceps extensor M.* (*ligamentum patellæ*) is inserted, and a bursa exists between the tendon of the upper part of the tubercle where the bone is smooth.

Posterior surface includes the back of each condyle, and presents the *popliteal notch* already referred to, a flattened rim, and a triangular smooth space below (the popliteal surface of the Tibia). Notice the groove on the back of the inner tuberosity, the articular facet

for the fibula on the back of the outer tuberosity, and above this a small oblique groove for the tendon of the popliteus.

Fig. 33.



Section of tibia and fibula in upper third, middle, and lower third. *T*. Tibia. *F*. Fibula. Three surfaces are shown in the horizontal section of the tibia, (*a*) anterior, (*i*) inner, (*p*) posterior, and should be traced in their changes as the section is made on the different levels. In the fibula, (*a*) anterior, (*o*) outer, (*p o*) posterior and outer, (*p i*) posterior and inner, (*p*) posterior (combined.) These should also be compared on the different levels.

2. **Shaft** prismatic, with sharp edge pointing forwards, and smooth, flat, or slightly convex surface inwards, thinnest at the junction of the middle and lower thirds (where fracture commonly occurs), curved with concavity towards the fibula (and this curve is greatly increased when the fibula is defective), apparently twisted inwards below.

It presents three borders—anterior, posterior, and outer; and three surfaces—inner, outer, and posterior (Fig. 33, T).

Anterior border extends from tubercle to the front of inner malleolus, is very sharp in the middle, and runs inwards below; to it is attached the deep fascia of the leg. *Posterior border* from below inner tuberosity to behind inner malleolus, rounded, not distinct. *Outer border* from front of facet for fibula on outer tuberosity to a hollow articular facet for the fibula on the outer side of the base, is sharp in the middle two-thirds, bifurcates below, gives attachment to the *interosseous membrane:* notice that the line of this border

ligament, and the *Biceps tendon* is attached in front of and behind the ligament.

2. **Shaft** long, irregular in shape, bent outwards towards its lower end, and apparently twisted outwards, one surface more deeply grooved (outer) than the other, another surface (anterior) being in many bones a mere line above the middle of the bone. It is however necessary to distinguish the separate surfaces carefully, as they indicate the attachment of different sets of muscles, and these surfaces are marked off by lines or borders, sometimes difficult to trace. It has four borders and four surfaces. (*See* Fig. 33.)

Borders. *Anterior*, extending from the front of the head, and forming the anterior margin of the deeply grooved outer surface, and in its lower fourth *splits* to form the boundaries of a well-marked triangular surface, that ends below in front of and behind the external malleolus.

Inner border or **interosseous line,** often not distinguishable from the last-named border in its upper half, extends from the back of the head, is separated from the anterior border by a narrow space (anterior surface), which widens in the lower two-fifths of the bone; the inner border ends by joining the anterior again in front of the external malleolus. The line gives attachment in its whole length to the *interosseous membrane*.

Posterior outer border, prominent, sharp, extends from the styloid process, twists backwards, and ends internal to and behind the external malleolus.

Posterior inner border traced from the inner extremity of the head, twists inwards and forwards, and joins the interosseous line in the lower fourth of the

bone. Near where these two lines join is the foramen for the nutrient artery.

Surfaces. *Anterior* is the space between the anterior and interosseous borders, narrow above, and often a mere line, broader in the lower half of its extent, lost again close to the malleolus. It gives attachment to the extensors (*extensor longus digitorum, Peroneus tertius, and extensor proprius pollicis*).

Outer surface deeply grooved in its upper third, becomes posterior below, and ends behind the malleolus; it gives attachment to the *Peroneus longus and brevis Ms.* The triangular surface on the malleolus is separated from it by the hindermost branch of the anterior border, and is subcutaneous.

Posterior surface between the outer-posterior and inner-posterior borders is flat, broad, and marked in its upper fourth by a roughness for the *Solæus M.;* it becomes internal below, and is rough at its lowest part for ligaments; it gives attachment in its lower three-fourths to the *flexor longus pollicis M.*

Internal only exists in middle three-fourths of the bone, between the interosseous and posterior-inner borders, sometimes marked by a rather prominent ridge; it gives attachment to the *Tibialis posticus M.*

[Mem.—This arrangement of borders and surfaces is the most natural, as it explains the attachment of groups of muscles to the bone.]

3. **Lower extremity** triangular, forming the external malleolus; it projects downwards lower than the inner malleolus, and its apex, which is placed posteriorly, is behind the level of the inner; its outer surface forms part of the triangular subcutaneous surface noticed in the examination of the anterior border of the shaft, and is directed rather

anteriorly; its posterior surface is grooved for the *Peronei* tendons, and is continuous with the outer surface of the shaft; its inner surface is rough above for the *interosseous ligaments*, is smooth and articular below and in front where it comes into contact with the astragalus, and has a deep, rough depression posteriorly, immediately under the tip of the malleolus for the *external lateral ligament* of the ankle-joint.

Articulations.—With two bones—the tibia above and below, and the astragalus at the malleolus.

Development.—Usually from three centres. One for the shaft, appearing shortly after that for the tibia; one for the lower end, in the second year; one for upper, in the third or fourth year. The lower epiphysis unites with the shaft in about the twentieth year, and the upper a little later, so that, unlike most bones, the epiphysis first to appear is the first to unite.

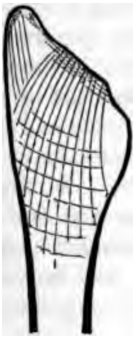
Mechanism.—As has been already pointed out, the bone appears to be placed as a solid but elastic tie-rod to the curve formed by the outer border of the tibia; and this function of it is more noticeable, when owing to its defective development the Tibia loses its support. Three examples of this peculiarity are recorded by the author in the "Journal of Anatomy and Physiology," vol. vii.

Although the fibula does not receive or transmit force perpendicularly from the knee to the ankle or vice versâ, yet it must not be forgotten that the wedging of the astragalus between the malleoli, in running, jumping, and standing, will distribute the force of concussion or pressure, and as we shall see by the architecture of the outer malleolus, this part

of the bone is evidently constructed with a view to this important function.

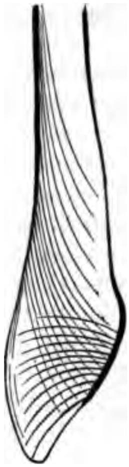
We notice in the bone a lateral curve, best marked towards the middle or lower third, the concavity being directed outwards; and an antero-posterior curve in the whole length of the bone, the concavity being forward and rather inwards. We notice also

Fig. 38.



Fibula, upper end.—Plan of construction.

Fig. 39.



Fibula, lower end.—Plan of construction.

the strongly marked ridges or borders which strengthen so much a bone otherwise extremely liable to fracture: the tendency to a spiral arrangement in these ridges gives the bone an appearance of being twisted, and it is peculiar that in this bone the apparent twisting is the reverse of that seen in other long bones. It appears to be twisted outwards.

Now these curves and ribs give elasticity and strength, so that the fibula is one of the most evidently elastic bones in the body. Owing to the comparative length of the bone, its elasticity is easily felt in the living subject by pressing the tibia and fibula together, and I have been for years accustomed to make use of this to determine the presence of fracture not involving the extreme ends; if the elastic rebound of the bone after pressure is not obtainable, it is evident that the bone is broken.

The architectural structure of this bone throws some light upon its functions in the human skeleton, and helps to show that a certain amount of the vertical pressure of the body acts through the fibula. A section through the upper end (Fig. 38) shows in the better-marked specimens an arrangement of curved fibres extending from the articular surface and spreading into the shaft, where they are crossed by other curved fibres nearly transversely. A few run separately into the styloid process and are nearly vertical. Now, in the majority of bones the arrangement is difficult to trace clearly, and beyond the portions marked in the diagram the cancellous tissue is simply porous and indefinite. Still the presence of these curved fibres is very strong evidence of pressure being exerted in the long axis of the bone, and when the position of the fibula with regard to the outer condyle is noticed it becomes more certain that the weight of the body, when carried through the external condyle of the femur and outer tuberosity of the tibia (as in standing on one leg), must be in part carried to the fibula. Perhaps it will be more evident if the force be traced from below, when the fibula

receives part of the upward force from the astragalus, for the same pressure which separates the malleoli when a man is jumping or bearing a great weight also forces the fibula upwards. A further evidence of the association of tibia and fibula for this direction of pressure is to be found in the fact that special diverging fibres are seen in the tibia springing from the articular surface against which the fibula lies.

At the lower end (Fig. 39) diverging curves start from the surface of pressure—from that surface which comes into contact with the astragalus, and these are crossed by other less distinct curves at varying angles. Now, it is noticeable here that, although the fibula is in contact with the tibia, and is somewhat thick in its shell at that point, no columns are seen in relation to that surface. Moreover, none are visible in the corresponding portion of the tibia. This must be taken in connexion with the fact that little or no pressure is exerted between these two surfaces, and we then see another corroboration of the view that these curved fibres are directly related to the lines of greatest pressure.

Means of distinguishing right from left.—Hold as if in your own body, with the lumpy, irregular end upwards, its small styloid process being behind, and the deep fossa at the lower end for the external lateral ligament backwards, then the smooth, well-marked subcutaneous triangular surface on the malleolus looks outwards and forwards—*i.e.*, points to side to which the bone belongs.

Points of importance:—

1. Head with peculiar styloid process projecting upwards behind.

2. Peculiar triangular subcutaneous surface above

the outer malleolus, looking forwards and outwards.

3. Peroneal groove at the back of the malleolus, and pit under cover of it.

4. Apparent twisting of bone outwards.

5. Always subsidiary to tibia in animals.

PATELLA.—PLATE VI.

Synonyms: *E.* Knee-cap, knee-pan. *G.* Die Kniescheibe. *Fr.* La rotule. *L.* Rotula.

Situation.—Placed in front of the knee somewhat in the same manner that the olecranon is placed at the back of the elbow, but attached to the tibia below only by ligament.*

Shape.—Rather heart-shaped, with apex downwards.

Parts.—Consisting of anterior and posterior surfaces, a rough base, and a prominent apex below.

Anterior surface rough, grooved longitudinally by the tendinous fibres of the *quadriceps M.* and covered in the recent state by a *bursa* which is liable to inflammation in housemaids and others working much on their knees.

Posterior surface chiefly made up of an articular surface which extends to the limit of the bone above but not below, separated into two nearly equal parts by a longitudinal ridge, the outer part being rather larger† than the inner and rather more concave. If these articular surfaces be examined carefully other ridges will be seen (Fig. 40), two running transversely across both surfaces near the upper and lower borders, and one running nearly vertically on the inner facet. These lines mark off

* Owen looks upon the patella to have its homologue in a sesamoid bone found sometimes in the biceps. The olecranon is then homologous with the styloid process of the fibula.

† The large outer facet is peculiar to man (Humphry).

minor facets, indicating contact with the femoral condyles in certain positions of the limb.

Base thick, bevelled at the expense of the anterior surface, gives insertion to *quadriceps extensor M.*

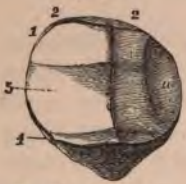
Apex pointing downwards, separated from the articular surface behind by a depression for the *ligamentum patellæ.*

Articulations.—With femur only by direct contact.

Development.—From a single centre appearing in about the third year.

Mechanism.—The patella is placed over the front of the knee for protection and leverage. When the patella is absent some other provision for similar mechanical leverage is always found. Thus in the Kangaroo and the Ostrich the tubercle of the tibia is prolonged, and in the Frog the tendon of the Tibialis anticus lies beneath that of the quadriceps. It forms a sliding fulcrum, and by this means economizes space, and its important action in the mechanism of the knee-joint will be referred to in considering that joint. Owing to the peculiar shape of the femoral articular surface, the patella comes into contact with bone only to a limited extent in the various movements, as indicated in Fig. 40. The direction of force through this bone is twofold, one perpendicular to the surface—and this is a force of compression, the bone being dragged against the femur; the other in its length—and this is a force of traction or extension: one is centripetal, the other centrifugal.

Fig. 40.



Patella.—Facets on articular surface.

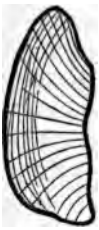
If sections be made through the bone, the can-

cellous tissue is seen to be composed of fibres which are arranged in various directions.

A vertical section (Fig. 41) shows a set of curved fibres springing from the articular surface behind and diverging as they pass forwards. to the front, and arranged so that they are at first vertical to the surface of pressure, and other curved lines parallel with both anterior and posterior surfaces, but best marked in front.

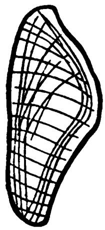
In a horizontal section (Fig. 42) those lines appearing parallel with the anterior and posterior surfaces are best marked, but here the posterior set are best seen. Other fibres run across the substance of the bone in the manner indicated in the diagram.

Fig. 41.



Patella.—Vertical section.

Fig. 42.



Patella.—Horizontal section.

In this construction we have evidence of admirable adaptation to the pressure always acting but always varying.

Means of distinguishing right from left.—Hold as if in your own body, with the apex downwards and the articular surfaces behind. Of these the outer has been described rhymingly to be stouter, the inner thinner.

Points of importance :—

1. Outer articular surface the larger.

2. In some animals the patella has a separate joint for the femur quite distinct from the knee-joint, and this is indicated in the human subject by the *ligamentum mucosum*, a synovial fold which runs from below the patella backwards to the intercondyloid notch of the femur.

Mechanism of the knee-joint.—The knee may be looked upon as the most important joint in the body, inasmuch as it is the largest and is in almost constant use.

It will be necessary to notice again roughly the peculiar anatomical features of the bones which enter into the formation of this joint—viz., the femur, tibia, and patella, and to remember that we have two joints in the knee, the patello-femoral and the tibio-femoral.

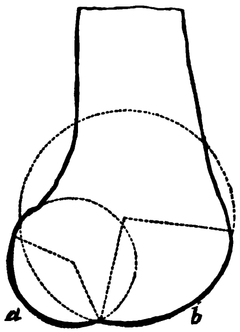
Femur.—In this bone we observe that the end is enlarged for firm support and for muscular leverage; that the inner condyle is the larger owing to the obliquity of the shaft (and in the same way the inner condyle of the humerus is the larger); that the outer condyle has the larger articular surface for the patello-femoral joint extending on the front of the bone higher than is the case in the inner condyle, and corresponding with the larger *outer* articular surface of the patella; that the two condyles (Fig. 24), are parallel behind, and that this part of their articular surfaces, which we have called "proper condyle surface," is separated in front by a curved line from a "patellar surface" on the outer condyle, and from an "oblique curvature" on the inner; that the latter curvature is separated by a curved line from the "patellar surface of the inner condyle;" that there is also a peculiar crescentic facet on the margin of the

oblique curvature; and that the inner third of each condyloid surface (*i.e.*, towards the notch) is marked off from the rest.

Moreover, certain curves, one plainly discernible in vertical section, have been referred to. In the outer condyle these are (Fig. 43)—

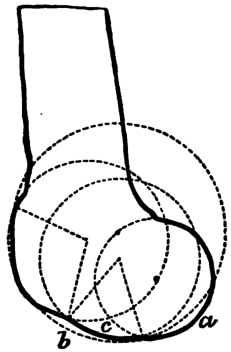
1. Curve of the condyle surface—an arc of about 120°, being part of a circle whose centre is situated

Fig. 43.



Section through outer condyle of femur, showing curves of (*a*) condyle surface and (*b*) patellar surface.

Fig. 44.



Section of inner condyle of femur showing curves of (*a*) condyle surface, (*b*) patellar surface, and (*c*) oblique curvature.

opposite the attachment of the posterior crucial and external lateral ligaments.

2. Curve of the patellar surface—an arc of about 120°, but of a much larger circle, whose centre is in the middle of the base on a level with the highest limit of the condyle surface, and whose plane is directed obliquely upwards and outwards.

In a section of the inner condyle we notice (Fig. 44)—

1. Curve of the condyle surface just as in the outer.

2. The anterior curve is now subdivided into two—one, the smaller, corresponding with the oblique curvature, and representing an arc of about 50°; the other, larger, belonging to the true patellar surface and involving an arc of about 100°. These arcs belong to circles of equal sizes, whose centres are placed in a line running upwards and forwards from the centre of the curve for the condyle surfaces, and each of these circles lies in an oblique plane, just as was noticed with that of the other condyle.

Tibia.—On the articular head of the bone we notice that the outer condyle is more circular than the inner, since rotation occurs here more upon a central axis, while the inner is more elongated, since the surface glides round against the oblique curvature of the inner condyle of the femur in the first movement of flexion. But we notice also that the bone shows a crescentic line on each articular surface, which indicates the limit to which a semilunar fibro-cartilage or washer overlies the bone; in fact, very little of the tibia comes into contact with the femur at any time, owing to the presence of this bevelled buffer. The spine stands up between the two articular surfaces, and performs important mechanical functions. For besides giving attachment to the semilunar cartilage, it gives rise to an obliquity of the articular surface of each condyle, so that each femoral condyle is prevented from being displaced laterally, and this obliquity of the surface and consequent obliquity of pressure explains the arrangement of bone fibres in the cancellous tissue of the head of the tibia (Fig. 34).

Patella.—In the patella we notice the various

minor facets which are indistinctly marked on the two larger facets (Fig. 40).

In extreme flexion the upper and outer facet (1) comes into contact with the outer femoral condyle behind the boundary curve which separates the "patellar" and "proper condyle" surfaces, while the peculiar facet (*a*) on the inner side lies against the crescentic facet on the edge of the "oblique curvature" of the inner condyle. It is only in this position of the limb that this facet is in contact with bone. When the knee is bent the lower part of the patella can be made to recede by pressure, and when the pressure is removed it springs back to its original position, since it is supported only by an elastic pad of fat.

In semi-flexion only the two upper facets (below the figures 2, 2) lie against the femur; one of these facets (1) was in contact during extreme flexion.

In semi-extension only the two middle facets (on a level with 3) are in contact with bone. In this position the greatest advantage is afforded to the large muscle of the thigh (*Quadriceps*) for leverage, and therefore it is in this position that the patella is most frequently broken, the upper two-thirds being wrenched from the lower third.

In complete extension the two lower facets (4), which are often run into one, are the only portions in contact with the femur.

When we look at the movements which occur in the knee-joint, we must bear in mind that it is surrounded by a bag or capsule which is loose in front but thickened on each side as lateral ligaments, so as to prevent anything more than the very slightest abduction or adduction, but allowing flexion

and extension along the condyle curves: and the capsule is also rather strengthened behind. But there are two curious bands passing from the tibia to the femur, or *vice versâ*, called crucial, since they cross one another like the bars of the letter X; the *anterior* or *external* is attached above to the inner and hinder part of the external condyle opposite the centre of the condyle curve, then passes downwards and forwards to the front of the inter-spinous pit, and this is the guiding band, as we shall see, to the rotation of the tibia upon the oblique curvature; the *posterior* or *internal* is attached above to the front of the inter-condyloid fossa, then passes downwards and backwards to back of spine and the inter-articular notch.

The movements in the tibio-femoral portion of the knee-joint are :—

1. Flexion and extension in an antero-posterior plane. This occurs between the tibia and the proper condyle surfaces, between the positions of half-flexion and complete flexion of the thigh (Fig. 45, F^2 F^3). The centre of rotation is opposite the attachment of the lateral ligaments and of the posterior crucial ligament.

2. Rotation along the oblique curvature of the inner condyle. This occurs between it and the inner condyle of the tibia, during the movement of the limb from semi-flexion to semi-extension (F^2 F^1). The radius of this curve is the anterior crucial ligament, which may therefore be looked upon as the guiding ligament of this motion.

3. Rotation round the axis of the limb. This is allowed of, to a slight extent, when the joint is flexed.

4. Abduction and adduction also occur to a very limited extent when the knee is bent.

If now the knee be examined in its different positions and movements, we shall find that

(*a*) In semi-extension, as when standing "at ease" (F^1), the femur rests on the anterior third of its condyles, and the crucial ligaments are not tensed.

(*b*) In passing to extension (F), as when coming up

Fig. 45.

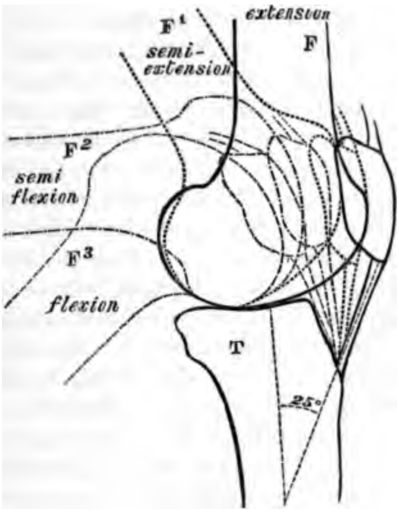


Diagram showing position of bones in the different movements of the knee-joint.

to "attention" at drill, the tibia rotates outwards along the oblique curve, the anterior crucial ligament acting as its guiding band, and becoming more and more tense as the screw motion is continued. This outward rotation of the tibia is the chief cause for the natural turning outwards of the foot in the erect posture.

(c) In complete extension the femur rests by its broad trochlear surface and oblique curvature.

(d) In passing from semi-flexion to complete flexion (F^2 to F^3), as in kneeling, the movement is practically antero-posterior, though not strictly so, as it is slightly curvilinear. In kneeling on one knee, you may notice that the hinder foot is inverted, partly due to the mechanism of the ankle, and partly to a slight internal rotation of the tibia.

In the erect position, it may be asked, why the knees do not give way from the pressure of the superincumbent weight, seeing that the line of gravity is behind the joint? This may be accounted for by remembering that flexion cannot occur without rotation, and that in standing upright the weight of the body is really resting at the knee-joint upon two screws and not upon a hinge, since the first movement of flexion is very marked rotation or screw movement, and it is evident that the tendency to motion is reduced to a minimum by this simple means.

These movements can be shown in the dead subject by making a pin project from the centre of one or both articular surfaces of the tibia, and carrying the knee from extreme extension to extreme flexion: the lines marked by the points of the pins upon the cartilaginous surfaces of the femur will indicate the course travelled along by the tibia. The original idea entertained of the action of this joint was that it was a simple hinge-joint, but Meyer showed this view to be inaccurate, and that there was a combination of gliding and rolling and rotation in it. Weber in 1853 pointed out the oblique curvature of the inner condyle, and the special curve of what we have termed the "condyles proper."

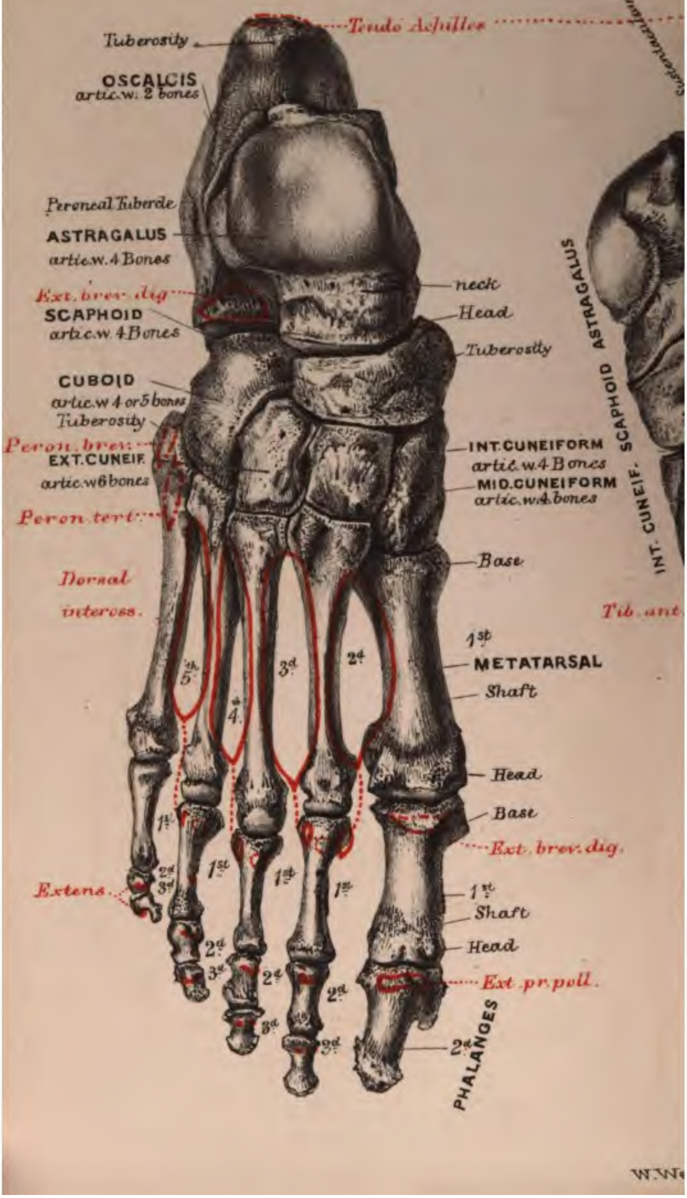
Goodsir then showed that the patella had a number of curious facets; Langer and Henle indicated the screw action of the joint, and Goodsir in 1855 went further, and insisted that the action was excessively complicated, that the screw was a double and a conical one, that there were two systems of screws, one between the front of the femur and the tibia, seen in extension, and another between the back of the condyles and the tibia, seen in flexion, but very slight, and that these were in opposite directions.

In the patello-femoral articulation we find a gradual movement of the point around which the powerful extensor muscles of thigh are passing to their insertion into the tibia as shown in Fig. 45. It is evident that in the position of extreme flexion the mechanical arrangement is such as to insure velocity, while in the upright position it is such as to insure strength, the muscles acting almost directly upon the tibia. Such provisions are manifestly requisite: rapidity of movement being most wanted when the limb is bent, and steadiness when it is straight, and supporting the weight of the body. Moreover, the shifting pressure of the patella allows each portion of the trochlear surface of the femur to recover itself from the effects of pressure, sometimes very severe. And here we may refer to the similar provision for alternating pressure on the surface of the patella: the minor facets indicated in Fig. 40 show that in different positions of the knee, the patella has different portions of it brought into actual contact with the femur.

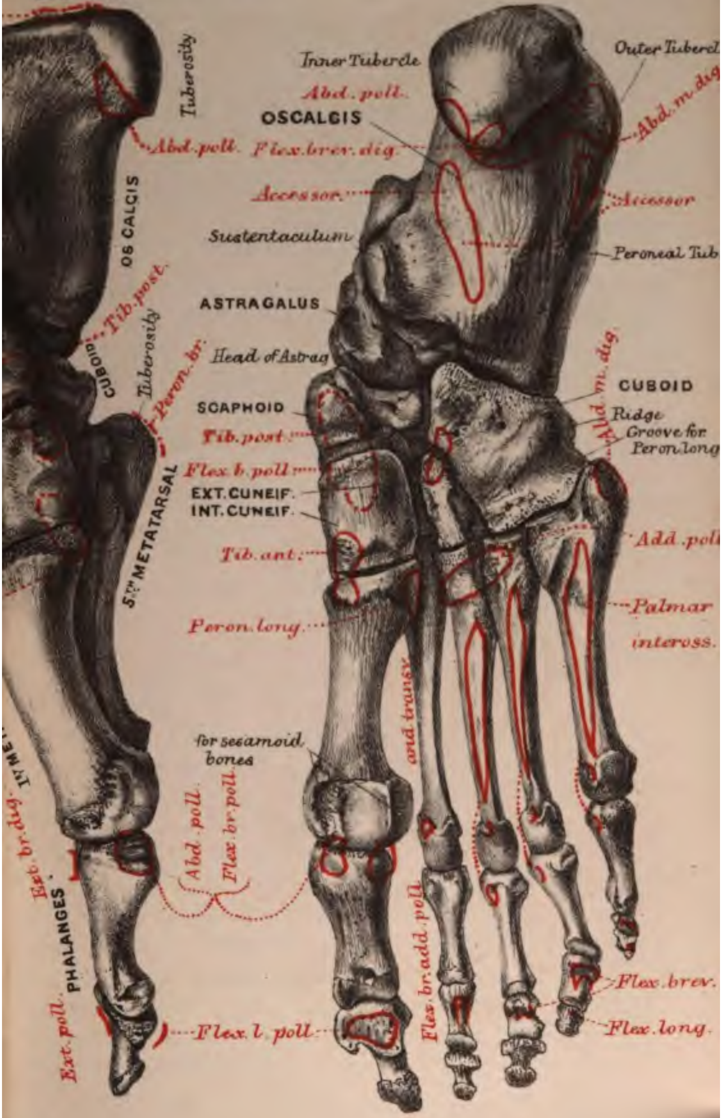
When the tibia is being rotated outwards in extreme extension, the patella would be thrown with undue force against the outer condyle of the femur

were it not for a peculiar provision. The lower fibres of the *vastus internus muscle* which forms the fleshy mass above the inner side of the knee are more developed and more advantageously placed to act upon the patella than the lower fibres of the *vastus externus* on the outer side. When therefore the muscles are acting forcibly to keep the limb upright, those lower fibres of the vastus internus by dragging on the inner side of the patella, take off the excessive pressure from the outer condyle, and keep the axis of the patella in a line with the axis of the tibia. It is not to be wondered at that when dislocation occurs, it is almost invariably on to the outer condyle.

UPPER SURFACE



ONES OF FOOT (right) SIDE VIEW — UNDER SURFACE PLATE VIII



TARSUS.—Plate VIII.

Synonyms : *E.* Instep. *G.* Die Fusswurzel. *Fr.* Le tarse.

Situation.—The tarsus consists of seven bones articulated together and occupying the hinder part of the foot. The bones of the leg rest upon it above, and the metatarsal bones articulate with it in front.

Shape.—The bones together form an irregular mass which at first sight appears to have little or no definite shape, but when carefully examined shows one of the most wonderful mechanical arrangements in the whole body. If looked at from the side, they form part of an antero-posterior arch which is completed by the metatarsus; if looked at from the front they form a transverse arch, and if seen from above they form a spreading arch with the concavity outwards.

Parts.—They may be divided into two sets—an inner, consisting of a large upper bone, the astragalus, which receives the weight of the body through the tibia, and has a flattened hollow boat-like bone, the scaphoid, in front of it, and in front of this three wedge-like bones, the cuneiforms, inner, middle, and outer, which receive the bases of the three inner metatarsal bones. On the outer side we find the massive heel-bone or os calcis, which articulates in front with another massive bone, the cuboid, the latter receiving the bases of the two outer metatarsals. This outer set supports the inner set, and as will be seen after-

wards takes the weight of the body in the erect posture, whereas the inner is arranged in curves in order to provide for great elasticity in the various movements and concussions to which the foot is liable when the heel is raised.

The older anatomists divided the tarsus into two sets of bones—a posterior, consisting of the astragalus and os calcis; and an anterior, consisting of the scaphoid, the three cuneiforms, and the cuboid; and for surgical purposes this arrangement is convenient, inasmuch as amputation (*Chopart's*) has sometimes to be performed along the line separating these two sets, and also between the anterior set and the metatarsus (*Hey's*). But considering the tarsus as a mechanical structure, the former, or longitudinal arrangement, is far preferable, as it assists materially in understanding the uses of the tarsus.

Before examining the separate bones it is important to notice that the astragalus receives the weight of the body and is placed like a key-stone or crown to the arch, the front, rounded end, or head, being supported by an elastic ligament (the *calcaneo-scaphoid*) which admits of its rising and falling like a spring; moreover, it is articulated with the os calcis and scaphoid in such a way as to allow of the lateral motion of the foot. Notice also that the scaphoid comes nearly, but not quite in contact with the cuboid except in rare instances, and that the middle cuneiform recedes between its neighbours, so that the second metatarsal is wedged into the tarsus.

Each bone has a dorsal surface, which in all cases is considerable; a plantar surface, which is rough for the attachment of strong ligaments and muscles, and in the case of the two outer cuneiform bones is reduced

to a mere line; also an anterior and a posterior and usually an inner and an outer surface.

In determining the side to which a bone belongs remember to place it in the position it would occupy in your own foot as you look down upon it; any other way of determining the bone will be worse than useless, for it will be misleading to the memory.

ASTRAGALUS.

Synonyms : *G.* Das Sprungbein, Knöckelbein. *Fr.* L'astragale. *L.* Talus, os balistæ.

Known by its large convex articular surface prolonged on to each side of the bone, by its rounded head and constricted neck, and by its having two articular facets below—one convex, the other concave and separated by a deep groove.

It is situated at the upper end of the inner set of bones and transmits the weight of the tibia vertically to the os calcis below. It is next in size to the os calcis, and is wedged in between the two malleoli.

Upper surface presents in its posterior half a broad, smooth, articular surface, convex from behind forwards, slightly hollowed from side to side to receive the corresponding surface of the tibia; it is narrow behind, so that when the foot is extended, lateral movement of the foot is allowed of; whereas when the broad front part of the articular surface is wedged in between the malleoli, the foot is fixed; the groove on this surface which causes the concavity from side to side is not truly median, but is so curved that the foot is inverted when pointed downwards. In front of this is the **neck**,* rough for ligaments. *Outer surface* presents a large triangular slightly concave facet for the outer malleolus, continuous with the upper surface;† in front of this the surface is rough and recedes abruptly to the neck of the bone. *Inner surface* more level than outer, presents a long and

* The neck is the part most liable to fracture, but it is more common for dislocation to occur to the head or to the whole bone.

† The surface for the outer malleolus looks rather upwards, and so transmits some weight through the fibula.

narrow horizontal facet near the upper border of the bone for inner malleolus; this is also continuous with the upper surface; the rest of this surface is rough, with one special depression below the middle of the articular facet, for the middle part of the *internal lateral ligament*. *Anterior* surface convex, rounded, forms the **head**, which is received into the socket of the scaphoid; the surface is longest from above downwards and inwards, and it is along this, its long axis, that movement chiefly takes place in the joint; it is continuous with a flattened or convex facet on the *under surface* where the head of the bone rests on the *calcaneo-scaphoid ligament*, and sustentaculum; behind this is a deep groove running obliquely from the outer side of the neck to the posterior and inner angle of the lower surface, and separating it from a larger concave facet behind. The two facets of the under surface, it must be noticed, are parallel, but are the reverse of one another: the anterior is convex, the posterior is concave, and the groove between them is converted into a canal when the os calcis is put in position; this canal is of mechanical importance, as it lodges the strong interosseous membrane round which rotation occurs. *Posterior surface* narrow from above downwards, almost entirely occupied by a groove which runs from without downwards and inwards, and lodges the tendon of the *flexor longus pollicis*. The posterior margin is very prominent.

Determination.—Hold with the broad articular surface uppermost and the rounded head pointing away from you; the large triangular lateral facet for the fibula will be on the outer side—*i.e.*, will point to the side to which the bone belongs.

SCAPHOID.

Synonyms: *G.* Das Schiffbein, Kahnbein. *Fr.* Le scaphoïde. *L.* Naviculare.

Known by its boat-like form, its posterior surface being hollowed out and the point of the boat being prolonged into a rough tuberosity, at the inner end.

Situated in front of the head of the astragalus, and behind the three cuneiform bones, its tuberosity forms a marked projection, which can be felt on the inner side of the foot.

Posterior surface hollowed out, oval, articular. *Anterior surface* larger than posterior, presenting three flat facets, the middle one being triangular, with the apex downwards; they articulate with the three cuneiform bones. *Upper surface* non-articular, rough, convex from side to side. *Lower* narrower than upper, convexo-concave from side to side, the inner extremity or tuberosity being separated from the rest of the bone by the concavity of this surface. *Inner surface* is the rough tip of the **Tuberosity**, and gives insertion to the *Tibialis posticus M.* *Outer surface* convex from above downwards, rough, but sometimes presenting a small facet for articulation with the cuboid.

Determination.—Hold with the concave surface towards you, and the convex non-articular surface upwards: the tuberosity points to the inner side of the foot—*i.e.*, away from the side to which the bone belongs.

INTERNAL CUNEIFORM.

Synonyms: *G.* Erstes Keilbein. *Fr.* L'os cuneiforme interne.

Known by its being somewhat wedge-shaped, with a rounded base, and a large kidney-shaped articular surface, which articulates with the first metatarsal bone.

It is the largest of the three cuneiforms, and is placed on the inner side of the foot, between the scaphoid behind and first metatarsal in front.

It presents five *surfaces*. *Inner* convex from above downwards, rough, marked below towards the front by a facet or groove, over which the tendon of the *Tibialis anticus M.*, with sometimes a sesamoid bone, glides in its progress to its insertion into this bone and the base of the first metatarsal; the upper anterior angle is very prominent. *Outer surface* rough, for *interosseous ligaments*, slightly concave, with a narrow articular surface near its upper and back borders for the middle cuneiform. *Lower surface* rough, rounded from side to side, forming the **tuberosity** of the internal cuneiform bone behind for the insertion of part of tendon of *Tibialis posticus M.*; to the front part is attached the *Tibialis anticus M.* *Posterior surface* is much smaller than the anterior, and is concave, and articular for the scaphoid. *Anterior surface* large, kidney-shaped, articular, convex from side to side.

Determination.—Hold with the large kidney-shaped surface away from you, and the tuberosity downwards; the rough slightly concave surface looks towards the outer side—*i.e.*, points to the side to which the bone belongs.

MIDDLE CUNEIFORM.

Synonyms: *G.* Zweites Keilbein. *Fr.* L'os cuneiforme seconde.

Known by its small size and simple wedge-shape, by its not being bent on itself like the external cuneiform, and by its having a lateral facet, which runs along the upper and back borders of the inner surface.

It is the smallest of the cuneiforms, wedge-shaped, with the base upwards, placed between the other two cuneiforms, articulating behind with the scaphoid, and in front with the second metatarsal bone.

It has five *surfaces*. *Upper* non-articular, quadrilateral, with the posterior inner angle projecting. *Inner* rough, rather convex, presenting a narrow facet along its upper and posterior borders, corresponding with that on outer surface of the first cuneiform. *Outer* rough, rather concave, presenting a single vertical facet along its posterior border. *Posterior* triangular, slightly concave, smooth for articulation with the scaphoid, continuous with the lateral facets. *Anterior* triangular, flat, articular for the second metatarsal.

Determination.—Hold with the base upwards, and that surface towards you which is continuous with the lateral facets; the base projects backwards towards the inner side, and that lateral facet which runs along the upper and back border points to the inner side of the foot—*i.e.*, away from the side to which the bone belongs.

OUTER CUNEIFORM.

Synonyms: *G.* Drittes Keilbein. *Fr.* L'os cuneiforme externe.

Known by being wedge-shaped, and apparently bent on its outer side, comparatively narrower than middle cuneiform.

It is situated between the middle cuneiform and cuboid, with the scaphoid behind and the third metatarsal in front. Like the previous bone, the base of the wedge is uppermost.

It has five *surfaces*. *Upper* rough, non-articular, the inner margin being shorter than the outer in consequence of the bend in the bone and the obliquity of the posterior surface. *Inner* smaller than outer, rough, and presenting a single vertical facet along its posterior border, corresponding with that seen on the opposed surface of the middle cuneiform; a small facet is seen at the upper anterior angle of this surface, and is for the side of the base of the second metatarsal bone. *Outer* rough, large, presenting a large rounded facet towards the posterior border for articulation with the cuboid; a small facet can be seen towards the upper anterior angle for articulation with the fourth metatarsal. *Posterior* less sharply triangular than the anterior, oblique, smooth, for articulation with the scaphoid. *Anterior* triangular, smooth for the third metatarsal bone.

Determination.—Hold with the base of the wedge upwards and the smaller triangular surface forwards; near the posterior aspect, the larger lateral facets are to be found; the larger side of the bone with its large oval or circular facet looks towards the cuboid bone or outer side—*i.e.*, towards the side to which the bone belongs.

OS CALCIS.

Synonyms: *E.* Heel-bone. *G.* Das Fersenbein. *Fr.* L'os du talon, le calcaneum. *L.* Calcaneum.

Known by its being the largest bone of the Tarsus, by its large double tuberosity and its overhanging process, upon which one of the two upper articular facets is placed.

It forms the heel, receives the weight of the body through the astragalus, which rests on it, and helps to form with the cuboid the strong outer arch of the foot, which constitutes, in fact, the lever for the muscles of the calf.

It has six *surfaces*. *Upper* irregular, smooth behind, and convex from side to side, its length here forming the length of the heel, which varies much in different races and individuals, the short heels requiring greater development of muscles in the calf; it is here covered by fat under the tendo-achillis. On the anterior half of this surface are two large facets, separated by a well-marked groove; the posterior facet occupies the middle third of the bone, is large, convex from before backwards, oval in outline, with its axis running forwards, outwards, and downwards; the anterior is also internal, is concave with its long axis parallel with that of the posterior facet, supported almost entirely by an overhanging process, the **sustentaculum tali.** They are separated by a deep groove, which, when traced outwards, ends in a large rough pit on the anterior third of the upper surface, and lodges the *interosseous ligament* which guides the movements of this bone and the astragalus and is twisted in the rotation of these bones;

both the facets articulate with the astragalus, and the anterior is sometimes double.

Lower surface narrow in front, broad behind, where it ends in two masses, or **tuberosities**, of which the **inner** is by far the larger, and gives attachment to three muscles (*abductor pollicis*, *flexor brevis digitorum*, and *abductor minimi digiti*), while the **outer** is small, prominent, and rough, for the *abductor minimi digiti M.*; the inner takes the chief weight of the body. From the under surface of the tuberosities Professor Humphry shows that bands of fibrous tissue continuous with the periosteum run into the skin of the heel, and are chiefly directed downwards and backwards. They doubtless result from the constant traction upon the skin in walking, and eventually act as checks against the bone slipping forwards over the skin. In front of the tuberosities the lower surface is rough, contracting to end in a rounded eminence, and giving attachment in its greater extent to the *long plantar ligament* (long calcaneo-cuboid); in front of the eminence the surface is depressed for the *short plantar ligament* (short calcaneo-cuboid); and along each side of it the *accessorius M.* is attached.

Outer surface flat, broad, covered only by skin in its greater extent, marked by an eminence or a prominent spur (**peroneal tubercle**) which separates two grooves, the upper for the *peroneus brevis*, the lower for the *peroneus longus M.*, the tubercle itself for a ligament (part of *external lateral*); in front of and above this tubercle the bone gives attachment to the *extensor brevis digitorum M.*

Inner surface hollow, smooth, with a marked overhanging process, the **sustentaculum tali**, which is grooved below for a tendon (*flexor longus pollicis*), and

marked on its side by another tendon (*flexor longus digitorum*). It gives attachment to a strong elastic ligament, *calcaneo-scaphoid*, the most important in the sole of the foot, since it supports the head of the astragalus, and if weakened the arch of the foot is impaired. The hollow surface is chiefly occupied by a muscle (*flexor accessorius*).

Posterior surface rough, rather triangular, marked by a transverse rough line, into which the *tendo-achillis* is inserted, the *plantaris* being sometimes separated from it; below this the bone is rough and subcutaneous, above it is smooth and covered by a *bursa* formed under the tendo-achillis.

Anterior smooth, articular, sinuous, triangular, the axis of the groove of the surface being directed downwards, inwards, and backwards. When articulated with the cuboid a notch is left below, and the upper margin of the os calcis projects as a tubercle, indicating the position of this joint; in *Chopart's* amputation (medio-tarsal) this must be remembered.

Determination.—Hold with the tuberosities towards you and occupying the under surface: the smaller broad tuberosity is on the outer side—*i.e.*, points to the side to which the bone belongs; the sustentaculum tali points to the opposite side.

CUBOID.

Synonyms: *G.* Das Würfelbein. *Fr.* Le cuboide. *L.* Os cubiforme, cuboideum.

Known by its cuboid shape and its prominent ridge and groove.

It lies in front of the os calcis, forms a wedge between it and the outer two metatarsal bones, articulating also with the side of the outer cuneiform.

Upper surface uniform, non-articular. *Lower* presents a well-marked transverse ridge, in front of which is a deep groove for the tendon of the *Peroneus longus;* the ridge ends in a tuberosity, and gives attachment to the *long calcaneo-cuboid ligament. Inner surface* presents an oval, flat, articular facet in its middle third, near the upper border, for the corresponding facet of the external cuneiform; the rest of the surface is rough for *interosseous ligaments. Outer surface* narrow, presents the **tubercle** and the commencement of the peroneal groove in front of it. *Posterior surface* obliquely placed, smooth, sinuous, triangular. *Anterior surface* also smooth and triangular, but flat and marked by a vertical ridge into two facets for the outer two metatarsal bones.

Determination.—Hold with the ridged surface downwards, the deep groove being on the distant side of the ridge: the tuberosity on the non-articular side points to the outer side of the foot—*i.e.*, to the side to which the bone belongs.

METATARSUS.

Synonyms: *G.* Der Mittellfuss. *Fr.* Le metatarse.

The five bones which articulate with the tarsus are called metatarsal bones, that belonging to the great toe being called the first, although, strictly speaking, this bone is rather a phalanx than a metatarsal bone, just as we have already seen in the first metacarpal bone.

Each metatarsal bone is a long bone, and has a base, or proximal, or tarsal extremity, a shaft, and a head, or distal, or phalangeal extremity. The first is thickest and shortest, the second is longest, and is wedged in between the three cuneiform bones, and the fifth has a projecting tuberosity at its base. Notice that the three outer are articulated in one oblique line to the tarsus, and that in order to remove the metatarsus from the tarsus (*Hey's amputation*) it will be easiest to commence by passing a knife behind the tuberosity of the fifth, separating the outer three, than to separate the first by passing the knife into the notch between the tuberosity of the internal cuneiform and the first metatarsal, then to dislodge the wedged base of the second by cutting on both sides, and then transversely rather behind. Notice also that the first metatarsal articulates with one tarsal bone, the second with three, the third with one, the fourth with two, and the last with one, exactly as was the case with the metacarpal bones.

Common characters of the outer four.—*Base* oblique, triangular. *Shaft* thin, compressed from side to side, convex above, concave below, nutrient foramen

running towards the head. *Head* compressed laterally with a convex articular surface at the end, whose long axis is from above downwards, and extends a good deal on to the lower surface. The head is a separate epiphysis in young subjects.

Peculiar characters.—**1st metatarsal** massive, short, apparently a modified phalanx. *Base* presenting a kidney-shaped articular surface for the internal cuneiform, a very projecting lower edge, on the outer side of which is a roughness for the insertion of the *peroneus longus M. Shaft* prismatic, with a foramen for the nutrient artery running towards the base. *Head* large, with two grooved facets below for the *sesamoid bones;* these are separated by a ridge.

Determination.—Hold with the base facing you, and projecting part downwards; the concave margin of the kidney-shaped articular surface looks to the outer side—*i.e.*, to the side to which the bone belongs.

2nd metatarsal the longest. *Base* presenting two small lateral facets for the outer and inner cuneiforms.

Determination.—Hold with the base towards you, the broad part of the wedge being uppermost; the angle which projects most is on the outer side—*i.e.*, points to the side to which the bone belongs.

3rd metatarsal. *Base* triangular, generally presents two lateral facets on the inner side, and one on the outer. Neither continuous with the triangular basal facet.

Determination.—Hold with the base towards you and broad part of the wedge uppermost; the angle which projects most is on the outer side—*i.e.*, points to the side to which the bone belongs.

4th metatarsal. *Base* irregular, with tarsal facet

not triangular but oblong, and continued into the outer lateral facet; on the inner side is a single separate facet for the third metatarsal.

Determination.—Hold with the base of the bone towards you, and the base of wedge-shaped articular surface upwards; the angle which projects most is on the outer side—*i.e.*, points to the side to which the bone belongs.

5th metatarsal. *Base* presents a large **tuberosity** on the outer side for the insertion of the *peroneus brevis M.* into tip, and *peroneus tertius M.* on to dorsum; the under surface is grooved longitudinally.

Determination.—Hold with the base towards you, and the grooved surface of the shaft downwards; the angle which projects most, and has upon it the tuberosity, is on the outer side—*i.e.*, points to the side to which the bone belongs.

PHALANGES.

These are smaller and shorter than those of the fingers, but in other respects the description already given of the latter will apply to them. The under side of each of the last phalanges is connected with the skin very firmly by means of strong radiating fibrous bands, which prevent slipping of the skin over the bone in the last part of the step.

Development of the Bones of the Foot.—The tarsal bones are developed each from a single centre, with the exception of the os calcis, which has an epiphysis for the tuberosity appearing in the 10th year and uniting about puberty. The fact of this epiphysis existing, makes the analogy between carpus and tarsus more marked, as the epiphysis corresponds with the pisiform, a bone not however united to the *cuneiform*. The centres appear in the following

order:—Os calcis 6th month, astragalus 7th, cuboid at birth, external cuneiform 1st year after birth, internal cuneiform 3rd year, middle cuneiform 4th year, scaphoid 4th or 5th year.

The metatarsal bones and phalanges resemble the corresponding bones of the upper extremity in their development, the epiphyses of the four outer metatarsal bones being distal, that of the phalanges being basal, and the metatarsal bone of great toe truly a phalanx in its development. The nuclei of the shafts appear early, about the 8th week, for the metatarsal bones, and a little later (9–10 weeks) for the phalanges; the epiphyses of the metatarsus appear between the 3rd and 8th year, those for the phalanges from the 8th to 10th year; they unite about the 18th to 21st year, the phalanges being rather the later. The so-called metatarsal bone of the great toe ossifies early, as might be expected from its size.

Mechanism of the Foot.—If we have had occasion to admire the mechanism of the hand, we have equal cause to admire that of the foot, since in it we find mechanical provisions for strength, elasticity and mobility especially adapted to the requirements of this wonderful part; and bearing in mind the fact that the weight of the body is constantly being exerted upon the foot, it fills us with admiration to see the arrangement by which so important a structure is protected from injury, and can move with the freedom and elasticity and propulsive power shown in jumping, dancing, and similar actions.

As in the hand, so here we find the component parts divisible into three sets, called here tarsus, metatarsus, and phalanges. The tarsus, as has already been pointed out, is divisible into rows, which anatomically and mechanically we prefer to arrange as two lateral rows

The whole are massed together into one semi-solid structure, but in this mass we see evidences of design, and can trace, but yet only imperfectly, the mechanical advantages resulting from it.

Looking at the inner side of the foot (Plate VIII.), we notice the antero-posterior arch, the summit of which supports the astragalus and through it the tibia, and the extremities of this arch are formed by the tip of the heel and the ball of the great toe, or more correctly the sesamoid bones attached to the latter. The same arch is seen from the outer side, but here it is modified, since the outer side of the foot, as we shall hereafter see, is required more for strength, and to act as the lever; consequently we find the bones massive, and coming down close to the level of the ground—in fact when great pressure is used several points come in contact with it; the two ends of this arch are formed by the heel and the tuberosity of the 5th metatarsal. In this arch it must be observed that the astragalus lies with its anterior end unfixed, supported by a strong ligament (calcaneo-scaphoid) which stretches from the sustentaculum to the tuberosity of the scaphoid—a special provision for breaking the violence of concussion—and an extension from this ligament and from the *tibialis posticus* tendon may be found spread over the inner side of the joint. The small sesamoid bones act as buffers to the joint at the ball of the great toe, which has, it must be remembered, to sustain shocks at different angles according to the position of the foot, and the irregularity of the ground upon which it alights; so that the ligaments are attached to two moveable bones, which in their turn are connected to muscles specially appointed to regulate and accommodate the movements of the foot *to varying* circumstances.

Looking now at a section of the tarsus we see the transverse arch arranged with peculiar regularity like wedge-shaped masonry, if we make the section through the cuneiform bones.

The third set of arches are seen in looking upon the dorsum (Fig. 46), and these have their convexity directed inwards, and are specially distinguishable on the inner side. It is these last mentioned arches which form the key to the arrangement of the bones of the tarsus, since the most frequent pressure is exercised in the long axis of the foot, as in jumping, running, dancing, and the like. Now it must be noticed that there is a considerable difference between the two sides, and the explanation of this is found in the different uses of the two sides of the foot. In standing, the massive outer half, consisting of calcaneum, cuboid, and fifth metatarsal, forms a solid bent rod resting on the ground by two or three points, and supports the inner half, consisting of astragalus, scaphoid, and cuneiform and metatarsal bones. This outer massive rod is for strength, particularly with

Fig. 46.

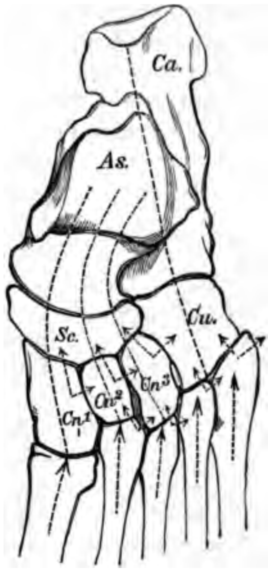


Diagram showing distribution of force in the tarsus. *Ca.* Os Calcis. *As.* Astragalus. *Sc.* Scaphoid. *Cn* 1, *Cn* 2, *Cn* 3. Internal, middle, and external cuneiform bones. *Cu.* Cuboid.

a view to its acting as the lever, the power being applied by the calf muscles into the heel close behind the weight which is being transmitted through the astragalus: the fulcrum in case of movement will be at the toes, for it must be noticed that the bases of all the toes are spread out by the superincumbent pressure, and movement takes place round them.

It is through the inner side of the foot that the numerous concussions of the foot are received, and in the annexed diagram, the direction of force coming in the axis of each metatarsal bone is shown to be modified in the tarsus. We have here, as in the hand, a provision for the distribution of force in the obliquity of the articulations, but we have a more definite provision for elasticity in the curvilinear arrangement.

Fig. 47.

Diagram showing upper surface of os calcis. *c*. Centre of rotation in interosseous ligament.

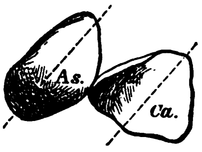
The movement allowed of between the separate bones is dependent in great measure upon the shape of the articular surfaces, and is often peculiar. It will simplify the consideration of these if we take first that between the astragalus and calcaneum. Now the inner half of the foot appears to move upwards and downwards more freely than the outer, and in doing so brings together or spreads the toes according as it is descending or rising. This is explained by the mechanism of the calcaneo-astragaloid joint. Here we notice two nearly parallel articulations within the concavities and convexities

reversed; we also notice a deep pit between them, which in the natural state is occupied by a strong interosseous band round which rotation occurs. If the two bones be fitted together it will be seen that rotation inwards of the head of the astragalus round this centre is accompanied with a sliding of the bone downwards: consequently in the living skeleton the inner side of the foot is depressed by such a movement.

The axis of this motion corresponds with that of the joint between the os calcis and cuboid, as might have been expected. When therefore the weight of the body is received upon the ball of the great toe, and the heel is raised, the metatarsal bones are spread by this rotation at the astragalo-calcanean joint; and the outer two are somewhat flexed on the tarsus, just as in the hand.

The front surfaces of the astragalus and os calcis present the one a convexity, and the other a concavity, but the axes of motion are parallel, as shown in Fig. 48, but when the scaphoid and cuboid are brought into contact with these surfaces, the cuboid has a greater range of motion, and hence can rotate to a certain extent round the scaphoid: moreover the scaphoid in descending recedes a little. Hence by downward movements at these joints the convexity of the antero-posterior arch is increased, the toes point inwards, and the cuboid descending depresses the outer border of the foot and turns the sole inwards.

Fig. 48.



Anterior surface of astragalus and os calcis.

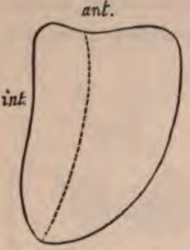
In the metatarsus we notice the great strength of the innermost bone which has to receive the greatest

amount of violence in the active movements of the body, and we notice too the compact arch formed posteriorly between the bases of the bones, contrasting in a marked manner with the separated heads which are spread out in standing, so as to give a broad basis of support.

In the phalanges we notice the same movements as in those of the fingers, but these movements are greatly cramped by the abuse to which the foot is subjected by ill-fitting boots.

Examining now the joints formed between the leg and foot, and between the tarsus and metatarsus, we observe at the ankle the two lateral projections, or malleoli, which prevent lateral displacement, and notice that the outer malleolus is the longer and more posterior—a point to be borne in mind in amputating at this joint. On the astragalus we remark that the anterior border is much broader than the posterior, and consequently the foot must be steadier when brought to a right angle with the leg, than when pointed downwards — hence the former position is maintained in riding, and when the foot is fixed with the rest of the limb upon a splint: moreover, dislocation of the tibia forwards is prevented by this arrangement. If the articular surface be carefully examined, it may be seen (Fig. 49) that its outer edge is much more curved than the inner, that the curve of the groove on the surface is similarly marked, with its concavity directed inwards, consequently there

Fig. 49.



Upper surface of astragalus, showing curves of rotation.

must be partial rotation outwards of the foot in flexion, and rotation inwards in extension, or pointing the toes downwards.

In extending the foot from a position of extreme flexion, there is to be noticed—(1) movement at the ankle-joint—which is really extension with a slight inversion, owing to the curve just mentioned; (2) movement at the astragalo-calcanean joint—which is really extension with depression of the outer edge of the foot, owing to the heel being pulled upwards; (3) movement at the tarso-metatarsal joint—which is extension with special depression of the fourth and fifth metatarsals.

At the metatarso-phalangeal joints the direction of movement is upwards and outwards, so that although the inner edge of the great toe is in a line with the inner edge of the foot when on the ground, it is thrown inwards when over-extended—*i.e.*, forced upwards, as occurs from most boots.

It may be well to point out in this place that in the construction of boots certain principles should be carried out, for, in consequence of an ignorance of the mechanism and structure of the foot, we are made to suffer days and years of punishment. The toes naturally spread out freely, somewhat like the fingers, and those who like sailors are accustomed to expose their feet without a covering, obtain a usefulness in them which astonishes more fashionable folks. A boot should allow free play of the toes, and the inner side should be quite straight, since when a normal foot is flat on the ground, the inner side of the great toe is in a line with the rest of the foot; square, broad-toed boots are therefore preferable to rounded or pointed ones, which jam the toes together,

and narrow the basis of support. The sole should be made broad—broader than the uppers usually—again to give a firm and broad support, and not to cramp the foot. The heel should not be raised to the absurd height which fashion sometimes condemns her sufferers to, since when the heel is raised, the toes are necessarily forced forwards, and squeezed together into the front of the boot. The heel of the foot usually presses downwards considerably in front of the heel of the boot, and this should be borne in mind, for thereby the arch or spring of the boot is destroyed, and the support which it should give to the arch of the foot entirely lost. Therefore the heel

Fig. 50.

Section of tibia and foot, showing plan of construction of cancellous tissue.

should be long from before backwards, and in case the arch of the foot be weak, this should be supported by a thin steel plate in the spring of the boot. The safest means of insuring a boot being suited to the foot, is to have a cast of the foot taken, and to induce the bootmaker to mould the boot to the cast, which may be run in metal.

The internal architecture of the bones (Fig. 50) is characteristic, and increases our admiration for the wonderful mechanism of this organ. In the astragalus the curved lines run in two main sets, one extending along the length of the bone, from the trochlea to the head, the other diverging from the posterior astragalo-calcanean articular surface; each of these therefore coinciding with the directions of greatest pressure: the first in the violent actions of the foot, as jumping, running, &c.; the last when the heel is on the ground, and the weight of the body (and possible extra weight) supported in standing.

In the os calcis the arrangement is peculiar. The fibres are in divergent curves in three main sets—one passing from the posterior astragalo-calcanean articular surface into the heel; another, from the anterior astragalo-calcanean joint downwards and forwards to the cuboid articular surface, and the third forming an inverted arch, but constructed of divergent curves which spring from the middle of the lower surface of the bone.

In the other tarsal bones there is an equally definite arrangement, corresponding with the lines of greatest pressure, as shown for instance in the antero-posterior axis of the scaphoid, internal cuneiform, and metatarsal (Fig. 50).

In the metatarsals we see an arrangement of divergent curves springing vertically from the articular base. These curves are in two series (in a vertical section), and belong respectively to the upper and lower surfaces, and are arranged with their concavities in opposite directions.

Similarly in the phalanges there are two sets of curved lines seen in a vertical section.

VERTEBRAL COLUMN.—Plates IX.–XII.

Synonyms: *E.* Spine. *G.* Wirbelsäule, Rückgrat. *Fr.* Le rachis. *L.* Columna spinalis, rachis.

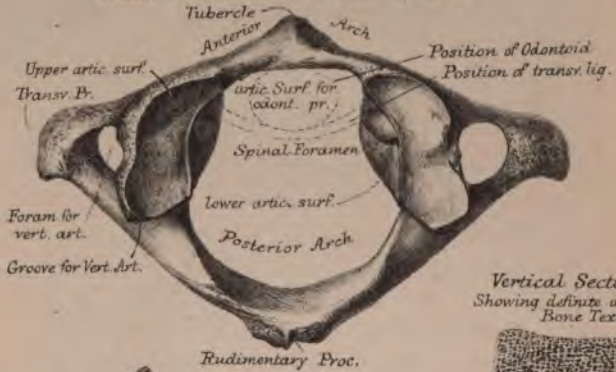
Situation.—This most wonderful piece of mechanical structure is a jointed column curved in the form of a double wave (Fig. 57), supporting at its summit the skull with its important contents, protecting in its interior the almost equally important spinal cord, and resting upon the circle formed by the pelvic bones which connects it with the lower extremities. It consists of twenty-four separate vertebræ, a massive bone, the sacrum, which results from the fusion of five or six vertebræ, and a small tail-bone or coccyx which is also composed of united rudimentary vertebræ. Of the twenty-four separate vertebræ, seven are situated in the cervical region, twelve in the dorsal, and five in the lumbar.

There are certain characters common to all the vertebræ, and there are others which are more or less shown in the different regions and serve to distinguish the cervical, dorsal, and lumbar respectively, while there are certain peculiar features which enable us to distinguish special vertebræ, viz.:—in the cervical region, the 1st, 2nd, and 7th; in the dorsal the 1st, 9th, 10th, 11th, and 12th; in the lumbar the 5th. Moreover it is possible to lay down the scheme for a typical vertebra, as Prof. Owen has done, and trace how each vertebra, and each modified vertebra approaches the archetype.

General characters.—For the purpose of seeing the general characters of vertebræ, take the middle bone

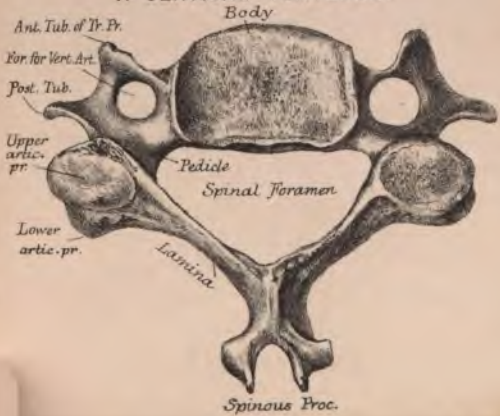
VER

FIRST CERVICAL VERTEBRA (ATLAS)



SECOND CERVICAL (AXIS)

A CERVICAL VERTEBRA.



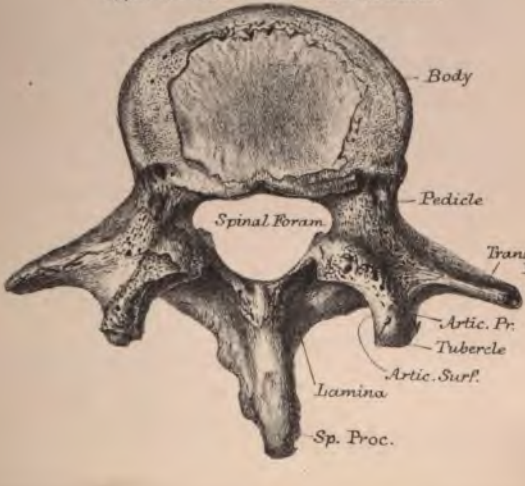
Vertical Section
Showing definite arran
Bone Texture

Horizontal Sect
Showing Veno

A DORSAL VERTEBRA.

A LUMBAR VERTEBRA.

Upper Surface of a Lumbar Vertebra.



of each region (4th, 12th, and 22nd), and compare them, seeing what features they possess in common.

They each enclose a large space, **spinal foramen,** having a thick solid mass in front called the **body,** the remainder of the ring being composed of an irregular arch, the **neural arch,** from which project several **processes,** and on which are seen certain **notches.**

The **body** is flat above and below for *inter-vertebral discs,* concavo-convex in front and rough for *muscles,* flattened behind where it forms part of the circumference of the spinal foramen, and having in the middle of the surface several small and one large foramen for veins.

The **arch** is composed of two anterior parts (**pedicles**), springing from the body, and two posterior parts (**laminæ**), the union of which forms the prominent spinous process.

Processes. *Spinous process* projecting backwards, and giving the name to the spine or spinal column from the number of pointed processes arranged along the column. *Transverse process* springs from the arch, generally about the junction of the pedicle with the lamina, and runs outwards. *Articular processes,* four in number, two upper and two lower, are appendages to the laminæ, and are facetted for articulation with the corresponding processes of adjoining vertebræ.

Notches, seen chiefly below, but also above the pedicles, and forming in the articulated skeleton, large, **inter-vertebral foramina** through which the various nerves pass, on leaving the spinal cord.

Spinal foramen, converted in the articulated skeleton into a long canal, **vertebral canal,** in which lie the spinal cord and its coverings.

Characters peculiar to groups :—

Lumbar.—Five in number, rarely six or four. Take now a lumbar vertebra, which will be known by its large size and the absence of lateral facets on the massive body. Examine each part of it separately, and the following peculiar features are found.

Body broad transversely, thicker in front than behind, flat above and below.

Pedicles strong, running directly backwards.

Laminæ short, deep, thick.

Spinous process horizontal, square, or axe-shaped.

Transverse process, springs from the junction of the lamina and pedicle, thin, directed rather backwards, rather in front of the articular process, sometimes ends in an epiphysis resembling a modified rib.

Articular processes, upper concave, look backwards, and inwards, further apart than the *lower*, which are convex, and look outwards as well as forwards.

Notch on the lower side of the pedicle is very deep.

Spinal foramen triangular, wider than in the dorsal region, smaller than in the cervical.

Dorsal.—Twelve in number, intermediate in size between lumbar and cervical.

Body somewhat triangular; usually described as deeper from before backwards than from side to side, but not really so; thicker behind than in front, and consequently producing altogether a curve with its concavity forwards, in this region; posterior surface rather concave from side to side; lateral surface presenting two half facets close to the root of the pedicle,

one near the upper, the other near the lower edge, each being for a half facet on the head of a rib.

Pedicles nearly on a level with the upper margin of the body.

Laminæ broad, thick.

Spinous process long, oblique, directed downwards and backwards, prismatic, tubercular.

Transverse process long, thick, directed upwards as well as backwards and outwards, the ends clubbed and presenting a concave facet on anterior surface for the tubercle of the rib, and springing from between upper and lower articular processes.

Articular processes, upper looking backwards and slightly outwards, rather in advance of the *lower*.

Notch larger than in the cervical region, smaller than in the lumbar formed on the lower side of the pedicle.

Spinal foramen circular, smaller than in the lumbar or cervical regions.

Cervical.—Seven in number, the first two unlike the rest.

Body broad transversely, thicker in front than behind, but shallowest in the middle; posterior surface flat; upper surface concave from side to side with projecting lip-like edges, rather convex from before backwards; lower surface smaller than the upper surface of the vertebra below, being embraced when articulated by the lips of the latter.

Pedicles directed outwards.

Laminæ narrow, long, thinner above than below, lower edges everted so as to overlap the upper edge of the next vertebra below.

Spinous process short, inclined slightly downwards, but chiefly horizontal, bifid at the tip.

Transverse process short, directed outwards, forwards, and downwards, bifid, springing by one root from the body, and by another from the pedicle, and enclosing a large foramen for *vertebral artery;* the upper surface deeply grooved for *spinal nerves.*

Articular processes, upper looking backwards and upwards, flat, oval.

Notch seen both above and below the pedicle, the upper continuous with a groove on the transverse processes.

Spinal foramen large, triangular, larger above than below.

[NOTE.—The transverse processes differ in length; the 3rd is usually longest, while the 1st and 5th are usually the shortest, probably to make room for the obliquity of the ribs above, and to admit of motion laterally.]

Peculiar characters of certain vertebræ.—

Fifth lumbar.

Body more massive than in other lumbar vertebræ, much thicker in front than behind because of its forming an angle with the base of the sacrum.

Transverse process usually very short, but thick and strong for ligaments.

Twelfth dorsal.

Body more like that of a lumbar, presents a single whole lateral facet for the twelfth rib.

Transverse process short, having no articular facet.

Articular process, lower are convex from side to side and looking outwards.

Eleventh dorsal.

Body somewhat like that of a lumbar, presents a single whole lateral facet for the eleventh rib.

Transverse process has no articular facet.

Tenth dorsal.

Body presents a single whole lateral facet above for the tenth rib.

Ninth dorsal.

Body presents a single half-facet above for part of the ninth rib; no half-facet below.

First dorsal.

Body, upper surface concave and with projecting lips; side presenting entire facet above for the first rib, and half-facet below for half of the second rib.

Spinous process horizontal, long, clubbed at the end.

[NOTE.—The body of the fourth dorsal vertebra is usually the smallest; from this point they increase in size as they are traced upwards and downwards.

The spinous processes become shorter and more horizontal from the eighth downwards.]

Seventh cervical.

Spinous process thick, long, clubbed not bifurcated.

Transverse process: vertebral foramen small or deficient in consequence of the vertebral artery not passing through this bone. Sometimes a small epiphysis exists on the tip of each, or of one transverse process, resembling in situation and form a rudimentary rib.

Second cervical or axis.*

Body, having on its upper side a tooth-like process, **odontoid process**, which is smooth in front for articulation with the anterior arch of the atlas, smooth behind for contact with the transverse or crucial ligament which binds it in place, rough above for ligaments (check or odontoid ligaments), anterior surface marked by a median ridge between two depressions for *longi colli M.;* posterior surface below odontoid sometimes rough for ligaments (posterior-occipito axoid); lower surface oblique.

Pedicles supporting in conjunction with body the upper articular process.

Spinous process large, strong, tubercular, but usually bifid or channelled below.

Transverse process small, not bifid, with *vertebral foramen* piercing it obliquely to carry vertebral artery outwards to the broader transverse process of atlas.

Articular process; upper in front of transverse process, *lower* behind.

Notches; upper behind articular process, lower in front of it.

Spinous foramen kidney-shaped.

First cervical or atlas.†

This vertebra has no true body, no pedicles, no spinous process, but consists of two lateral masses joined by anterior and posterior arches. Of the whole ring thus formed each lateral mass constitutes about a fifth, the anterior arch one-fifth, and the posterior arch two-fifths.

* Synonyms: *G.* Die achse. *L.* Vertebra dentata, epistropheus.

† Synonym: *G.* Drehwirbel.

Anterior arch; convex in front and presenting a central tubercle for ligaments, concave behind, and smooth for articulation with the odontoid process of the axis which represents the body of the atlas.

Posterior arch larger than the anterior, presenting a tubercle posteriorly in place of a spinous process. The bone is marked by a deep groove on its upper surface, immediately behind the lateral mass, and this is sometimes bridged over by a spicule of bone so as to convert the groove into a foramen; it lodges the *vertebral artery*, and the groove can be traced to the vertebral foramen. The under side of this arch is notched behind each lateral mass for the passage of nerves.

Lateral mass consists of articular processes, transverse process and certain tubercles. *Articular processes* different above and below; the *upper* being concave, oval, oblique, with the long axis running forwards and inwards, so as to bring the two upper articular surfaces nearer together in front than behind, and make the anterior arch smaller than the posterior; the *lower* being flat, oval, and oblique. *Transverse processes* long, strong, bifid, clubbed, inclined downwards, perforated by the vertebral foramen which leads to the groove seen on the upper surface of the posterior arch. The tips of the transverse processes are separated more widely than those of any other cervical vertebra. *Tubercles* seen on the inner side of the lateral masses, between the articular processes; they are for the attachment of the crucial or transverse ligament.

It will be seen from the shape of these two bones, the atlas and axis, that very different movements are provided for in their several joints. Nodding (nutation) and extension of the head are obtained by movement between the atlas and the bone above it (the occipital), rotation of the head with a side motion between the atlas and axis.

Development of the vertebra.—From eight or nine centres, three being primary, and seen in the 7th or 8th week of fœtal life. The primary are for the body, and for each half of the arch; they unite about the 3rd year The secondary are seen in the tip of each transverse process about puberty, and two or a single one at the tip of the spinous process about the same time. Lastly, a thin plate is formed on the upper and lower surfaces of the body about the 20th year.

In the lumbar region two other epiphyses are seen on the articular tubercles.

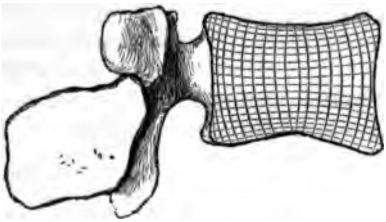
In the first lumbar, and in the lower cervical, separate centres are sometimes seen in the transverse processes indicating the tendency to the development of supernumerary ribs.

The *axis* is developed from six centres, the primary nuclei being for each lateral mass, and one or two for the body; while a little later two appear in the odontoid process, and sometimes there is a third near its summit.

The *atlas* is usually developed from three centres, a small one in the anterior arch in the 1st year, one in each lateral mass in the 7th or 8th week: these unite in the 3rd year, and join the anterior arch in about the 8th. Sometimes an extra centre is seen in the posterior tubercle.

Internal architecture.—If a vertical section be made through the body of a vertebra from before backwards, it will be seen that the bony fibres of the cancellous tissue are arranged in two directions, vertically and horizontally. In the accompanying diagram (Fig. 51) the vertical fibres are shown not to be rectilinear but curved, and to have their concavity directed towards the centre of the bone. They therefore do not correspond with the outline of the surface, which has its concavity looking in the opposite direction. Langerhaus depicts them

Fig. 51.



Vertical median section of the body of a last dorsal vertebra.

as perfectly vertical lines, but this is certainly incorrect, and the advantage gained by curved lines is obvious in securing elasticity with equal strength. This accords curiously with an observation of Mr. Ward's, that it has been found that wheels whose spokes are slightly curved possess far greater durability and power of resistance than those with straight spokes.

The horizontal fibres are slightly curved parallel with the upper and lower surfaces, and therefore with their convexities towards the interior of the

SACRUM.—Plate XIV.

Synonyms: *E.* Holy bone.* *G.* Das Kreuzbein, Heiligbein. *Fr.* L'os sacrum. *L.* Os basilare.

Situation.—The sacrum is the direct continuation of the vertebral column, being in fact only a fusion of five or six separate bones, which in the fœtus are separate. It is placed between the last lumbar vertebra above, the coccyx below, and the two innominate bones on the sides.

Shape.—Wedge-like with its base above, curved forwards below, perforated by large lateral foramina.

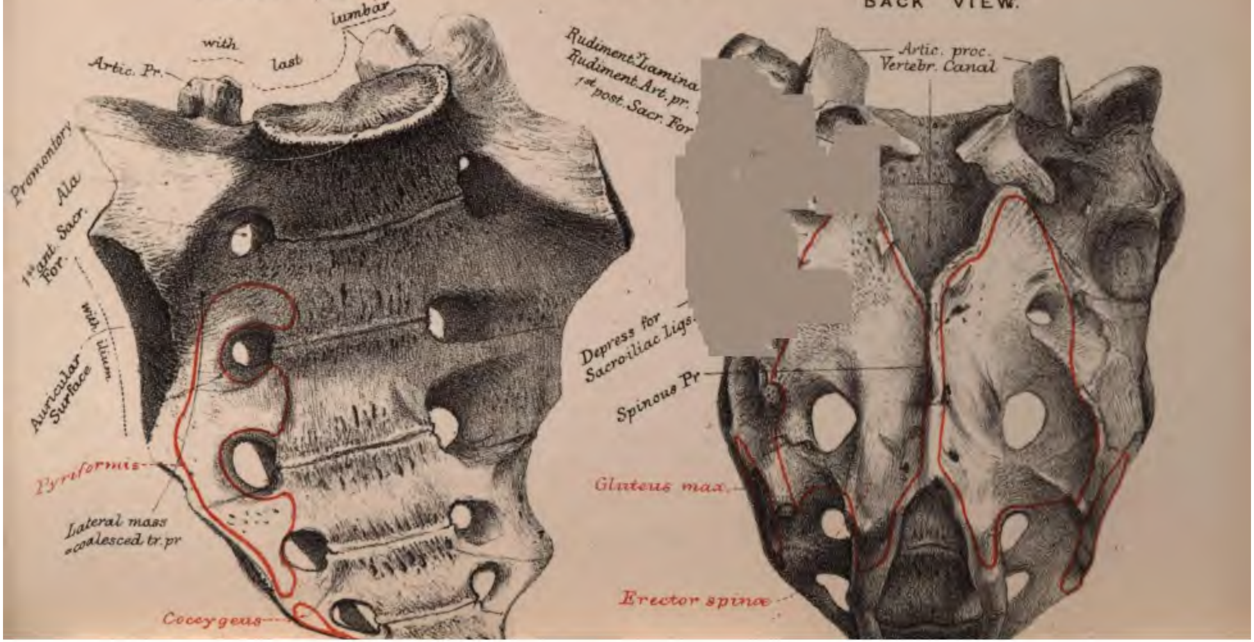
Parts.—It presents a base, apex, anterior, posterior, and two lateral surfaces, and a canal (the sacral canal) runs its whole length.

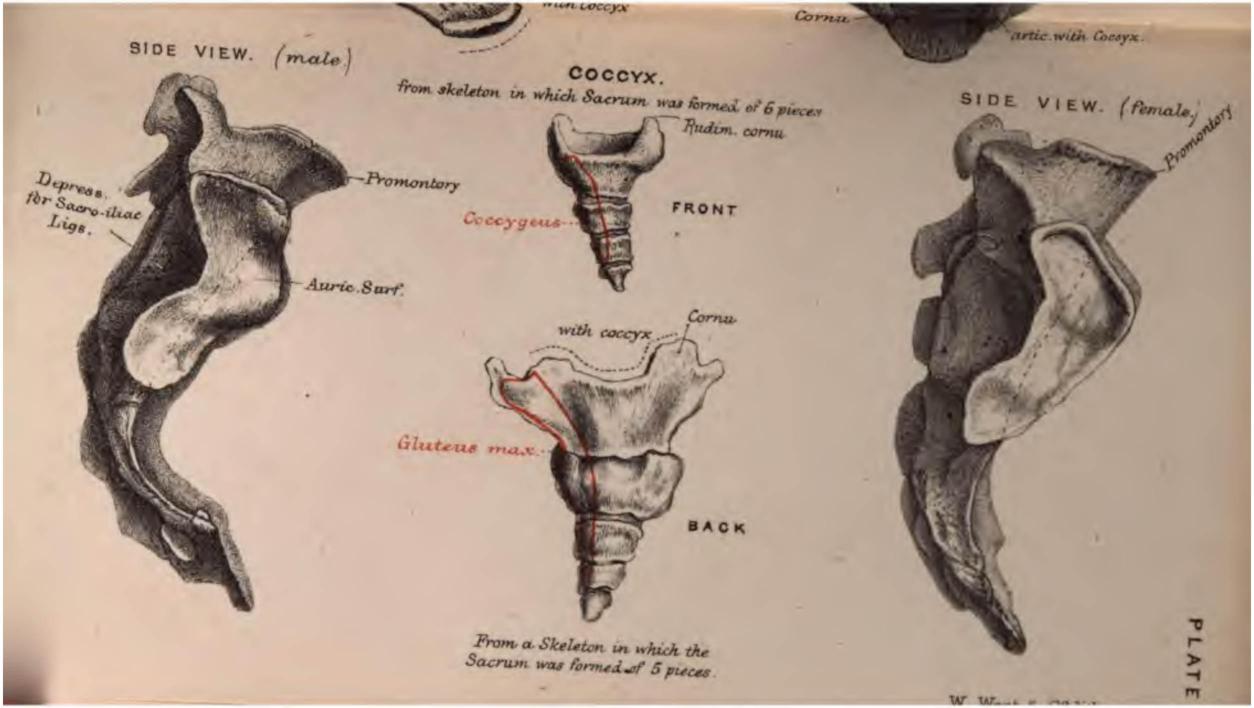
Anterior or Pelvic surface smooth, concave, especially from above downwards, the concavity being more marked in the male than in the female. The upper edge of this surface projects forwards, and is called the **promontory.** It presents indications of the original division of the bone into (usually) five vertebræ by the presence of four **transverse lines,** which are homologous with intervertebral substances; at the extremities of these lines are four sacral **foramina,** homologous with intervertebral foramina: and, running outwards from them are four **grooves** for the sacral nerves converging outwards.

Posterior or Dorsal surface convex, narrower than the pelvic, presenting in the middle line three or four prominent spinous processes, which are coalesced into a ridge. At the lower end of this is a triangular

* Hudibras. Part III. Canto II. line 1615 and following.

SACRUM.


FRONT VIEW.
Artic. Pr.
with
last
lumbar
Promontory
Ala
1st ant. Sacr. For.
with ilium
Auricular Surface
Pyriformis
Lateral mass coalesced tr. pr
Coccygeus
BACK VIEW.
Rudiment Lamina
Rudiment Art. pr.
1st post. Sacr. For
Artic. proc.
Vertebr. Canal
Depress for Sacroiliac Ligs.
Spinous Pr
Gluteus max.
Erector spinæ



with coccyx
Cornu
artic. with Coccyx.
SIDE VIEW. (male)
COCCYX.
from skeleton in which Sacrum was formed of 6 pieces
Rudim. cornu
SIDE VIEW. (Female)
Promontory
Depress. for Sacro-iliac Ligs.
Promontory
Coccygeus
FRONT
Auric. Surf.
with coccyx
Cornu
Gluteus max.
BACK
From a Skeleton in which the Sacrum was formed of 5 pieces.

PLATE

aperture due to the incompleteness of the fifth arch, but the edges of this aperture are thickened and prolonged downwards in the form of horns (**sacral cornua**), which are for articulation with the coccyx. Between the spines and the lateral borders a broad groove exists on each side, in which are found—(*a*), the coalesced laminæ; (*b*), some rather irregular tubercles representing the articular processes situated between and behind (*c*), the posterior sacral foramina, four or five in number. These latter are continuous with the anterior sacral foramina but are smaller, and transmit the posterior sacral nerves. Beyond these is the commencement of the lateral masses.

Lateral surface consists of the coalesced transverse processes, and presents two distinct portions—(*a*) an anterior ear-shaped surface (**auricular**), for articulation with a similar surface on the Ilium; and (*b*) a rough irregular depressed surface behind for strong sacro-iliac ligaments. Below the inferior lateral angle is a notch which is converted into a foramen when the coccyx is articulated with it and transmits the 5th sacral nerve.

Base is oblique, and presents—(*a*) a large oval articular surface for the body of the last lumbar vertebra, behind which is (*b*) the sacral canal continuous with the vertebral canal above; (*c*) two articular processes rising from near the junction of the modified pedicles and laminæ; (*d*) a notch or groove in front of the articular processes, and assisting to form the last intervertebral foramen for the last lumbar nerve; (*e*) the upper surface of a large **lateral mass**, consisting of coalesced transverse processes, smooth and continuous with the Iliac bone.

Apex presents only the projecting body of the last sacral vertebra, and articulates with the coccyx.

Sacral Canal triangular; it opens below between the sacral cornua, and contains the cauda equina, or the termination of the spinal cord and its membranes, as well as the leash of sacral and coccygeal nerves springing from the cord. The anterior and posterior primary branches of the sacral nerves pass off from the canal, through the anterior and posterior sacral foramina respectively.

Articulations.—With the ilium, the last lumbar vertebra, and the coccyx.

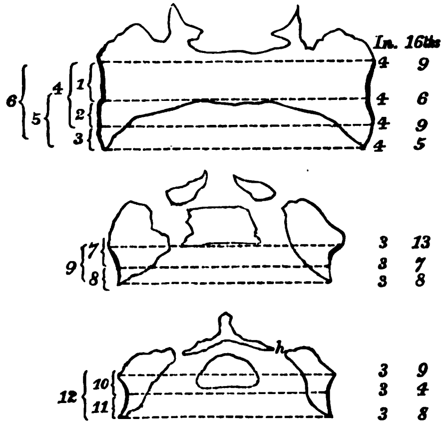
Peculiarities.—The male sacrum differs considerably from the female, and the distinction is of the greatest importance in determining the sex where an adult skeleton has been found. In the male the promontory is usually very marked, and the curve of the anterior surface is sharp and pronounced: the whole bone too is usually narrower than in the female.

Sometimes the posterior arches are not perfectly closed, and then a bulging of the spinal membranes occurs, and the malformation is called spina bifida.

Development.—Very much after the manner of vertebræ. In the *sacrum* it commences from three centres for each constituent vertebra, but in each of the first three or four the anterior part of the lateral mass is developed from an additional centre (6th to 8th month). Plates are formed at a later period on each of the bodies, as with vertebræ generally. Separate laminæ are also found on the lateral borders (18th to 20th year), representing apparently the epiphyses of the transverse processes in a typical vertebra; the upper of the two lateral plates connects

the upper three, the lower the last two component vertebræ. The lower arches and bodies are the first

Fig. 55.



Three sections of the sacrum at different levels from above downwards (Ward).

The numbered brackets indicate portions of the sacrum lying between the lines of measurement, and the annexed table shows the respective tendencies of each portion to displacement—

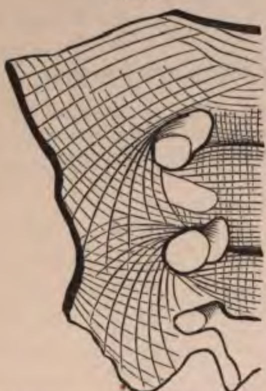
No.	1	resists	anterior	dislocation	by	3	
,,	2	,,	posterior	,,	,,	—	3
,,	3	,,	anterior	,,	,,	4	
,,	7	,,	anterior	,,	,,	6	
,,	8	,,	posterior	,,	,,	—	1
,,	10	,,	anterior	,,	,,	5	
,,	11	,,	posterior	,,	,,	—	4
						18—	8

so that the bone is specially arranged with a view to resist forward dislocation in the proportion of 18, to backward dislocation 8. Of the combinations, No. 4 is neutral, while the remainder are all protective against forward displacement.

to unite (2nd year), and the lower vertebræ are the first to be fused together (18th year).

Mechanism.—This bone acts as a peculiar wedge, as has been referred to in speaking of the innominate bone. In the first place, the whole bone is wedge-shaped, and supports upon its base the weight of the spinal column. But it is not a simple wedge, for, as seen in Fig. 56, the outline of the edge is undulating, and therefore the bone is locked firmly. Again, it is wedge-shaped from before backwards, and is so constructed that if sections be made horizontally through it at different levels (Fig. 55), we find that its anterior and posterior margins are alternately broader, so that there is little or no possibility of displacement forwards or backwards, and its general wedge shape prevents downward displacement. The bone is therefore locked in every direction by its peculiar shape, and by means of the powerful ligaments which connect it with the neighbouring bones. This locking is all the more necessary, because the bone is placed obliquely to the spine, but the obliquity of the articulation adds to the safety of the brain and spinal cord against concussion.

Fig. 56.



Sacrum.—Plan of arrangement of cancellous tissue.

Internal architecture.—In this compound of numerous vertebræ we trace out an arrangement of structure specially adapted for the pressure to which it is subjected from above and at the side. In a vertical section from side to side

(Fig. 56) we notice, first, a more or less vertically directed set of fibres in the bodies, not truly vertical but slightly curved, having their concavities towards the middle line; secondly, a set running from the upper surface obliquely outwards to the iliac articulation, curving more and more downwards as they pass, and others springing from the upper edge of the first sacral foramen until they run nearly vertically to the second foramen; thirdly, a set curving downwards from the second (and other similar ones probably from the other foramina) and impinging partly upon the outer, partly upon the lower, surfaces; fourthly, a set running at first parallel with the iliac articular surface and curving inwards below; fifthly, a small but distinct series running from the lower part of the same surface and diverging as they pass inwards.

In these arrangements we cannot but recognise a wonderful provision for strength and elasticity, and particularly for protection against the pressure which comes from above and from the sides.

Points of importance:—

1. The bone consists of five or six vertebræ coalesced.
2. Peculiar articulation with the innominate bones.
3. Difference between male and female.

COCCYX.—Plate ~~XIV.~~ X

Synonyms: *E.* Huckle-bone, whistle-bone (from its supposed resemblance to a cuckoo's bill; κόκκυξ, a cuckoo). *G.* Das Steissbein, Swanzbein. *Fr.* L'os coccyx. *L.* Os coccygis.

The coccyx is a continuation downwards of the sacrum, and consists of about four rudimentary vertebræ, sometimes five, and more rarely three. The first piece is broad, and possesses (*a*) an articulating surface above and below belonging to the modified body; (*b*) two lateral projections, and (*c*) two prominent horns (cornua) for articulation with the sacra cornua. The second piece is flattened. The third and fourth are mere nodules.

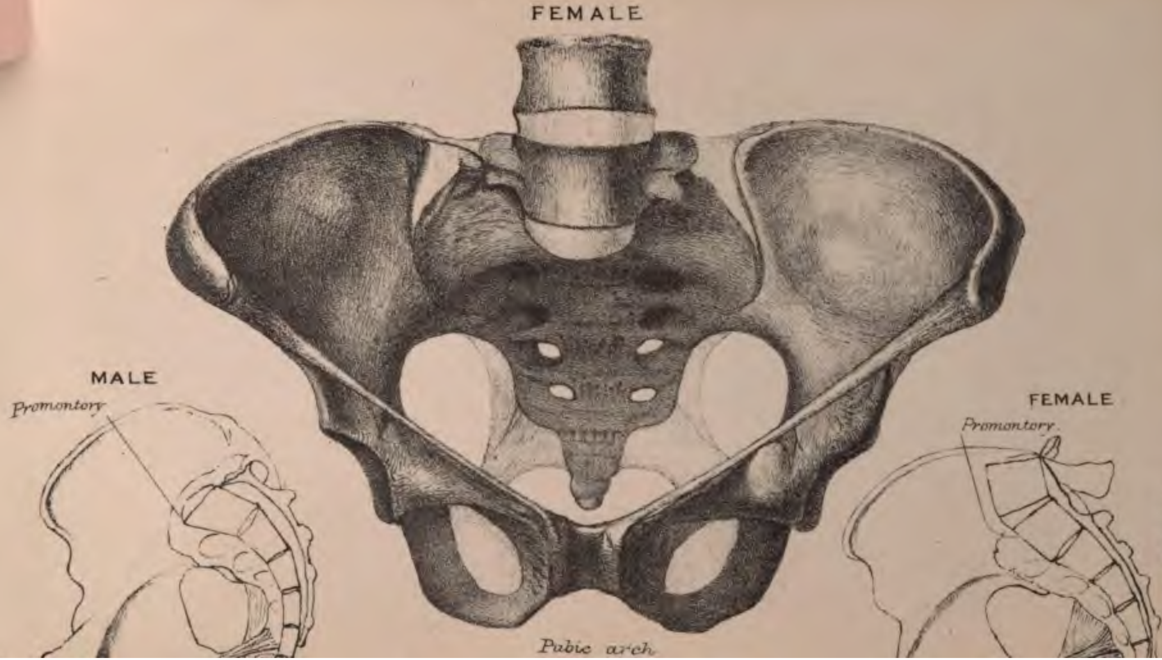
In middle life the first piece is usually separate, while the remainder are fused together. In advanced life the first is united with the last, and all with the sacrum, but this occurs sooner in males than in females.

Development.—In the coccyx each component vertebra is incomplete, and usually developed from a single centre, but sometimes the upper have two. Ossification begins in the first part about the time of birth; in the second, in the 5th to 10th year; in the third, from the 10th to the 15th; in the fourth, from the 15th to 20th years.

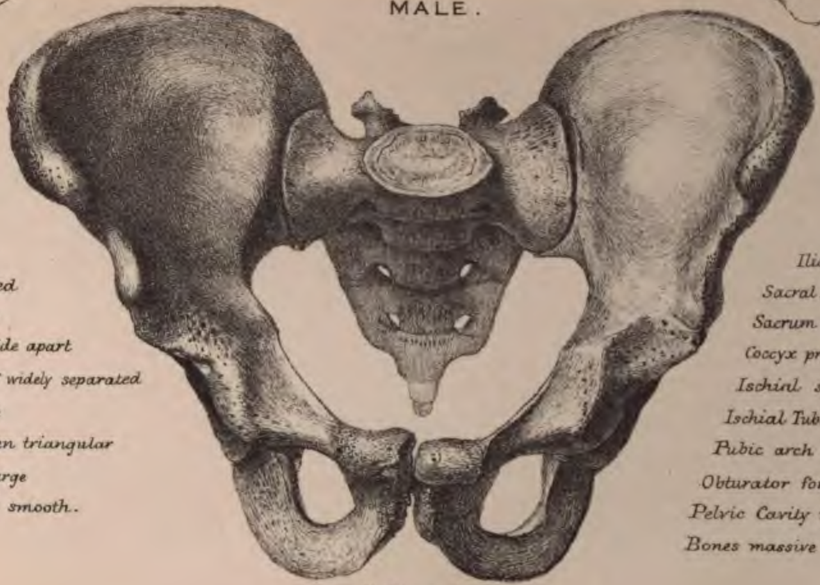
Spinal column as a whole.—Now that we have examined the characters of the vertebræ of each region, and the peculiarities of certain vertebræ in each group, it is necessary to look at the spine as a whole.

It is a wonderful mechanical structure, and well

MALE AND



MALE.



FEMALE

Ilia expanded
Sacrum flattened
Coccyx moveable
Ischial spines wide apart
Ischial Tuberosities widely separated
Pubic arch large
Obturator foramen triangular
Cavity of Pelvis large
Bones light and smooth.

MALE

Ilia vertical
Sacral Promontory sharp
Sacrum sharply curved
Coccyx projecting forwards
Ischial spines projecting
Ischial Tuberosities closer
Pubic arch narrow
Obturator foramen oval
Pelvic Cavity narrower
Bones massive and rough.

worthy of careful study. It is a jointed column, combining strength, mobility, elasticity and lightness; supporting by means of levers and muscles the chief weight of the body; capable of movement in every direction, yet containing and protecting the spinal cord—an organ only next in importance to the brain itself, and peculiarly susceptible to injury.

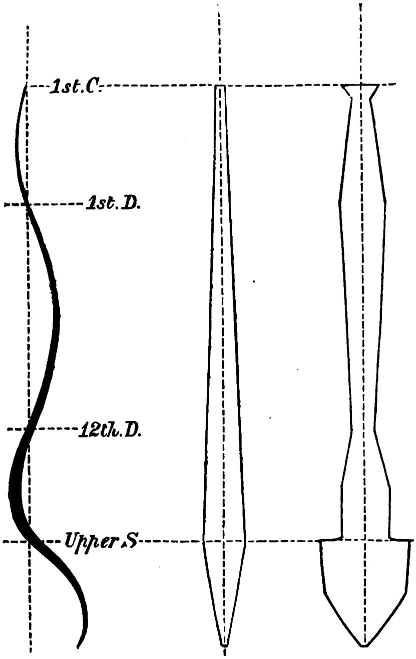
We have said that strength, lightness, freedom of movement, and elasticity, are the features of this spinal column These features in part result from the characters of the numerous bones which form it, but they are also in part owing to the presence of strong, abundant, elastic substances lying like a series of washers between the bones and uniting them together. These intervertebral substances constitute about a fourth of the entire length of the column; elasticity and movement are provided for by this structure.

Considering the spine as a whole, let us examine first its length and its curves, then take the surfaces and examine the features each presents.

Length.—This averages about 23 inches, or one-third the height of the body, and of these 23 inches, 5 may be allowed to the cervical, 7 to the lumbar, and the remaining 11 to the dorsal. This is a point which you may make a note of rather than attempt to remember, but it is well to recollect about the average length of the column, for this does not much differ in persons although their height may differ considerably. The difference in height of individuals depends rather upon a difference in length of the lower limbs than in a difference in the trunk. You will notice this at a dinner party when all are sitting

on chairs of equal height, the difference in stature is not easily perceived until persons rise from the table.

Fig. 57.



Curves of spinal column seen from the left side. Pyramids formed by the bodies. Outlines of transverse process.

Curves.—These are three: the thoracic curve is longest and deepest, the lumbar next, and cervical least. The thoracic may be taken first, because it is most easily fixed in the memory. It is the back of a cylinder, and its concavity must therefore look

forward. The other two counterbalance it and look in the opposite direction. The lumbar corresponds with what is called the hollow of the back.

Besides these three curves, another, a lateral one, is usually found in the dorsal or cervico-dorsal region. The spine here usually projects towards the right side, owing to the more frequent use of the right arm, the muscles of which come largely from this part of the column. Bichat gave this explanation as an improvement upon that of Cruveilhier, who in his "Traité d'Anatomie," expresses his belief that the curvature was due to the pressure of the aorta, a large artery which lies on the left side of the spine. Bichat was fortunate enough to meet with a case in which the aorta was out of place, and on the right side, but the man being right-handed his spine had the usual right deviation. Professor Otto records also a similar case.

Cause of the curves.—The cervical and lumbar curves are in great measure due to the greater thickness of the bodies of the vertebræ in front; and the lumbar in the same way, but in the dorsal region the chief cause of the curve is found in the inter-vertebral substances. There are also elastic ligaments (ligamenta subflava), always on the stretch behind the bodies of the vertebræ, and these will be brought into action more in the lumbar and cervical regions than in the dorsal, which is almost fixed.

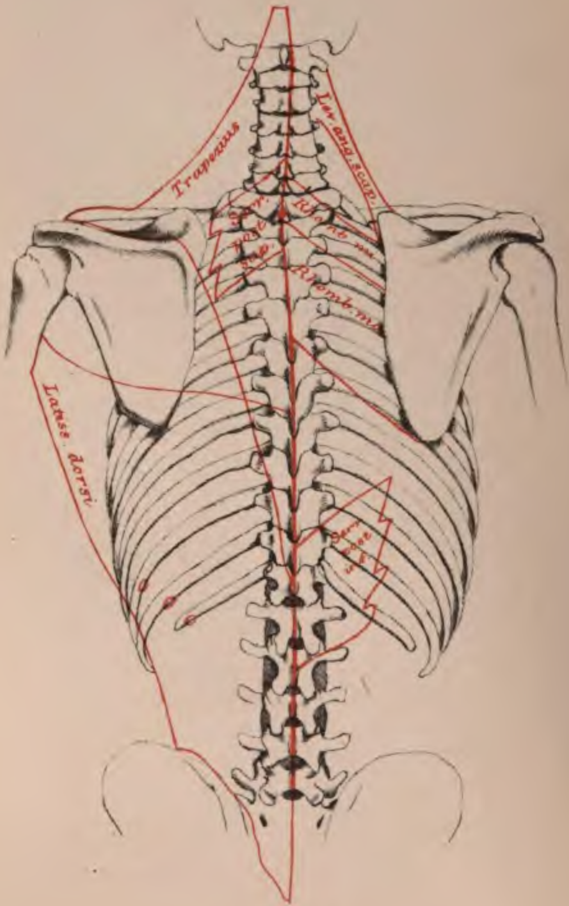
Object of the curves.—Their object or result is undoubtedly elasticity. They diminish, for instance, the jar which a fall or suddenly sitting down produces. Now a curved column is more adapted to variations in the direction of pressure than a straight one, and it has been experimentally proved that the

amount of weight capable of being borne by a three curved elastic column like the spine is about nine times as great as by a straight inelastic one. Again, the curves are important in bringing the line of gravity of the body through the acetabula, or rather through the middle of the line joining them, and at the same time allowing special freedom of room for the viscera contained in the bony cavities of the thorax and pelvis. They protect also the brain, which is placed on the summit of the curved elastic column.

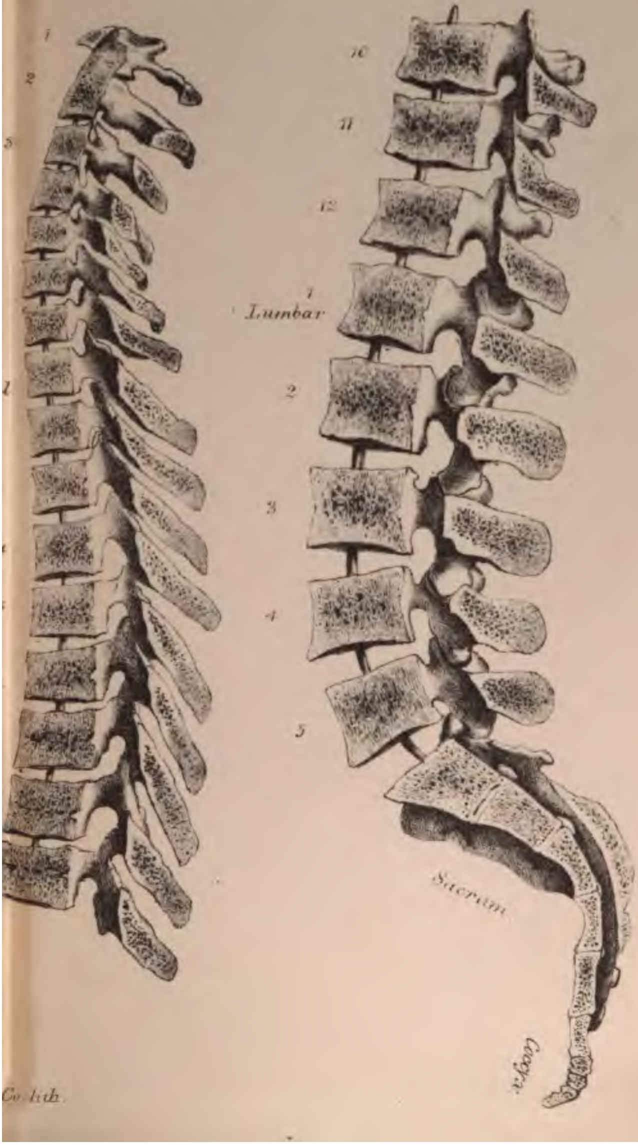
Pyramids.—We have now taken the curves of the spine, and before carefully examining each of the surfaces which the vertebral column as a whole presents, let us look at the building of this column. Is it simply a column—an uniform cylinder or a graduated pyramidal one, or an irregular one? Place the spine before you and examine it. Take a side view and you see that it is a tapering column, a pyramid in fact resting on the sacrum. Take a front view, leaving out of mind the transverse processes, which are merely brackets, so to speak, for the attachment of levers, and now it is evident that the column is a series of pyramids, and not a single one, as it appears to be on a side view.

Beginning below the sacrum is seen to be an inverted pyramid. Upon the base of this is a long pyramid, for the bodies (and arches) of the lumbar and dorsal vertebræ gradually diminish as they are traced upwards to the 4th dorsal. This is pyramid No. 2. Upon this is a third pyramid, which has its base inverted, for the vertebræ become broader now up to the 1st dorsal. Upon this is placed a fourth pyramid, which consists of the lower cervical, gradually diminishing up to the 2nd. And upon the

SPINE (*back view*)



SPINAL COLUMN (*vertical section*) PLATE XII.



Co. lith.

summit of the axis comes the atlas with its still broader burden above—the cranium.

Including the sacrum then, we find a series of four pyramids supporting the atlas, and the extremes of these are to be seen at (*a*) the tip of coccyx, (*b*) base of sacrum, (*c*) 4th dorsal, (*d*) 1st dorsal, (*e*) 2nd cervical. These remarks refer, you must remember, to the solid column, that is, to the bodies (and arches) but not to the transverse process, and simply to the front view. The solid part of the column then—*i.e.*, the bodies and intervertebral substances, form a simple pyramid, as viewed in one aspect—from the side, and a complex pyramid in another aspect—from the front or back. It is evident that the pyramidal form gives strength, but this will not explain the series of pyramids seen from the front.

Now as nothing exists without an object, there is evidently some purpose in this arrangement. In determining this it must be borne in mind that the most moveable part of the column is the cervical, and the most protected and immovable is the sacral, while the dorsal is very limited in its powers of movement.

The sacrum is a wedge, adapted by its base to support the whole of the rest of the column; moreover it is a wedge of peculiar construction. It is more or less on the principle of a toothed or sinuous wedge, and so becomes a locked pyramid very little liable either to be displaced or to force apart the two innominate bones between which it is placed.

Upon this sacrum stands the second pyramid, constituting nearly three-fifths of the total length of the column. This is broad below, where movements of flexion and extension are freely allowed of, but where little external support is given. The upper part of

this pyramid is narrow, for it is here that very little more than rotatory movement occurs, and where much support is given by the ribs and ligaments.

Higher up this column becomes broader for the purpose of affording a broad base upon which the cervical pyramid may rest. And the cervical pyramid is broad like the lumbar, for it is very little supported by neighbouring structures, and even more than the lumbar has to allow of extremely free motion, including flexion, extension, lateral movement, and rotation of a peculiar kind; but then, unlike the lumbar, it has not a very great weight to support, for the head is not so heavy as to require the solidity of a lumbar vertebra to support it in the neck.

Side by side with these pyramids, let us consider the outline formed by the extremes of the transverse processes (Plate XII.) and compare them with what we have just examined; for it is necessary not to confound the two.

Among the lumbar the broadest transverse process is the 3rd.

Among the dorsal, the last is the narrowest owing to the ribs becoming more oblique, and they increase in width as you trace them upwards to the 1st.

Among the cervical they diminish in size from the 7th to the 2nd, but the 1st stands out far beyond the others.

Here then we have a double pyramid for the lumbar, a single inverted pyramid for the dorsal, and an erect pyramid for the cervical, bearing at its summit the atlas.

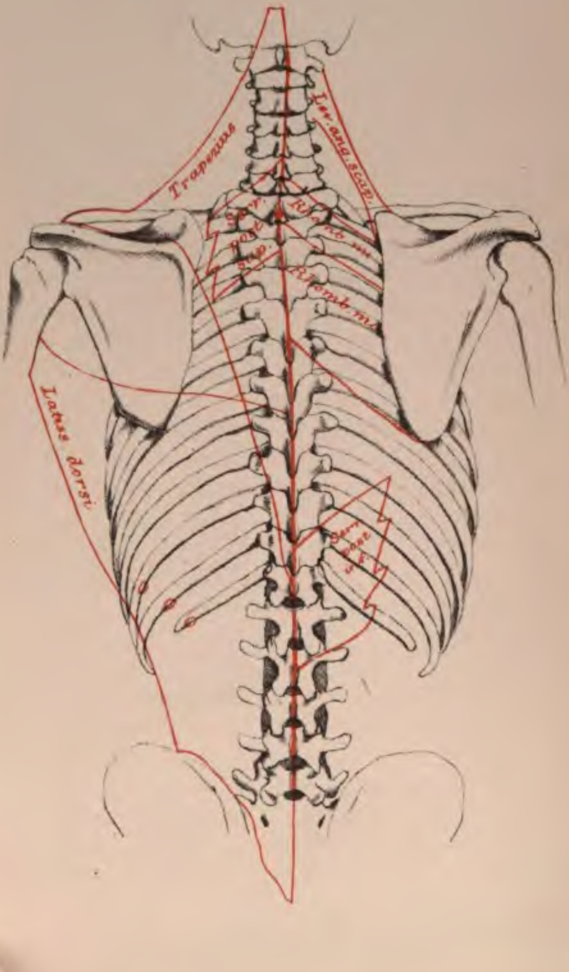
These transverse processes are thus arranged with a definite object apparently. In the neck they are small and light; for the muscles attached to them

are not so powerful as those below. In the dorsal region they are larger, for the ribs now have to be partly supported by them. In the upper dorsal region they are more prominent and more horizontal, for the ribs leave the spine more horizontally than below; in the lower dorsal region the ribs become more and more oblique, and this obliquity of the ribs explains the smallness of the transverse processes of the upper two lumbar vertebræ. In the middle of the lumbar region the transverse processes are much the strongest, for it is here that very powerful muscles are attached (*erector spinæ, multifidus spinæ, quadratus*), but the lower ones are diminished in size on account of the projection of the haunch-bone in this situation.

Surfaces.—Now take the vertebral column before you and examine it again. It has a front, a back, two sides, a summit, base, and a canal.

Looking at the anterior surface or *front*, the bodies are seen to form a set of four pyramids, as already described, alternately inverted and erect, supporting the atlas. You observe also the outline of the transverse processes, forming a double pyramid for the lumbar, an inverted one for the dorsal, and an erect one for the cervical region, these again supporting the atlas. Notice one thing particularly here—how much further out the transverse process of the atlas stands than that of the axis, and this prominence of the transverse process when dissected out sometimes puzzles the student or examinee. Now these cervical transverse processes are perforated by a "vertebral foramen" for an artery, the vertebral artery, which runs from below upwards into the head. It is very easily exposed as it runs obliquely outwards from the

SPINE (*back view.*)



tinue into one large muscle; and several of such muscles will be found attached to articular tubercles in the loins, and transverse processes in the back, or to transverse processes in the back, and articular processes in the neck. Thus the dorsal transverse processes are thrown further back than the others. In fact they are behind the articular process.

(5) In this view you will examine the projection of the spinous process. The cervical are more or less short and horizontal, the dorsal long and oblique, and the lumbar square, large, and horizontal. The 1st cervical has practically none; the 7th stands prominently out, and is easily felt under the skin. It is called the vertebra prominens, and to it is attached a strong ligament, the ligamentum nuchæ, much more strongly developed in animals whose trunk is horizontal, and in whom, therefore, the head requires more mechanical support. This view of the spinous process has given the name to the spine.

(6) The articular process will come better in the consideration of the view of the posterior surface.

Looking at the spine from *behind* you notice again

(1) The outline formed by the tips of the transverse process.

(2) That formed by the arches and bodies.

(3) The articular processes with their tubercles in the lumbar and cervical regions.

(4) The laminæ becoming deeper as they are traced from above downwards.

(5) The spinous processes represented by a tubercle on the atlas are bifid in the cervical region.

(6) The vertebral groove is the hollow along the side of the spinous process. In the back the transverse processes being continuous with the laminæ

enter into the formation of the groove; in the neck and loins the groove is limited by the articular processes, and by the tubercles of the transverse processes respectively.

The *summit* of the spinal column presents the upper surface of the atlas together with the odontoid process of the axis.

The *base* will be at the tip of the coccyx.

The *vertebral canal* opens above into the cavity of the skull, and below is terminated at the sacral opening. It is triangular in the neck, narrow and rounded in the back, triangular again in the loins.

Mechanism of the spine.—Incidentally this has been referred to in some measure in considering the various bones, and therefore only the chief points of interest, or such as have not been already noticed in this complicated mechanical structure, will here be dwelt upon. Roughly, we may consider the mechanism of the spine with regard to its statics and dynamics separately. Under the first head we notice how *strength* is obtained by the gradually increasing breadth of the column as we trace it downwards (Fig. 57) by its internal structure (Figs. 51–54), and by its many projecting points which allow of the attachment of powerful muscles, whose duty it is to retain parts in position as well as to move them.

Elasticity is especially provided for in this wonderful column by its compensating curves, which make it in principle like a spring letter-weigher, and this elasticity is especially required in the more violent shocks to which the column is subjected in jumping, falling, &c., not only to protect the limbs and body, but especially to save the brain from injury. The curved outlines of the bones give further elasticity,

and this is again increased by the curved arrangement of the bone fibres in their interior. But a special provision for still further elasticity is found in the curious discs between the bones (intervertebral discs) whose importance is evidenced by their extent, for they together form about one-third of the whole length of the spine in the living subject, and continued pressure upon them by the weight of the body during the day reduces the height of an ordinary man by about a quarter of an inch by the end of the day.

Diffusion of shock is provided for by the number of separate bones, and the varying obliquity of their articulations.

Freedom for movement is insured by the column consisting of so many separate bones and joints.

With regard to the dynamics of this part we notice the numerous *levers*, small and great. The whole spine is one large lever, whose fulcrum is at the hip-joint, (Fig. 23), and each separate bone is a lever, whose fulcrum varies. The *pulley* is not exemplified, but the *inclined plane* is seen in the wedge joint of the sacrum and in the oblique joints of the different bones, more especially in the cervical region and at the junction of the last lumbar and sacrum.

The movements allowed of may be briefly summarized.

Flexion and extension are freely permitted in the cervical and lumbar regions, but less in the dorsal on account of the position of the thorax. The greatest amount of backward movement is allowed of in the cervical, the greatest forward movement in the lumbar region; but it must be remembered that the backward motion of the head upon the atlas increases the apparent extension of the cervical region.

Rotation round vertical axis.—This true twisting of the spine only occurs in the dorsal region. In the lumbar region (Fig. 58) the movement round the centre of the body is prevented by the articular processes, and movement round the centre of the curved articular surfaces is limited to the lateral giving way of the intervertebral substances.

Fig. 58.

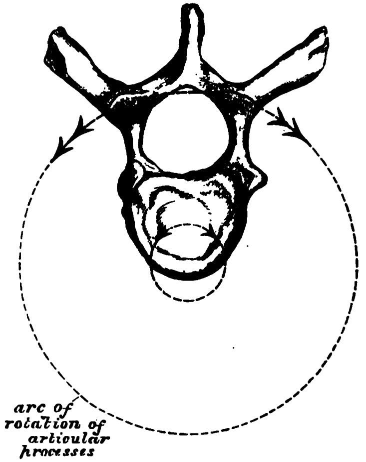
Lumbar Vertebra. The curves of the articular surfaces preclude the possibility of rotation without separation of the bodies.

In the cervical region the movement is peculiar and not round a vertical axis, except at the joint between atlas and occipital bone.

In the dorsal region (Fig. 59), however, the centre of the body corresponds with that of the articular curve, and consequently we find that in rickets and other spinal deformities rotation in this part is not uncommon, and the result naturally is to throw one side of the chest forward.

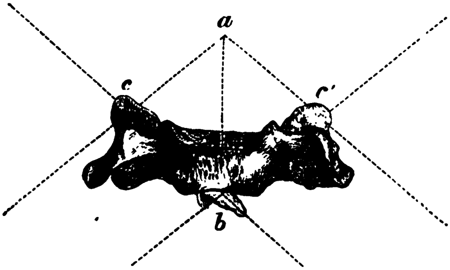
Rotation round an oblique axis.—This is seen in the cervical region, and is indicated in Figs. 60 and 61.

Fig. 59.



Dorsal Vertebra. The curves of the articular surfaces allow of rotation round a centre situated in the bodies.

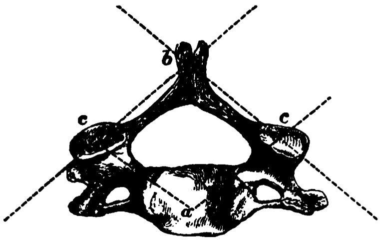
Fig. 60.



Cervical Vertebra, showing rotation round an oblique axis.

The cause of this is the obliquity of the articular surfaces, and the result is that in rotating the neck the head is thrown to one side. This combination of

Fig. 61.



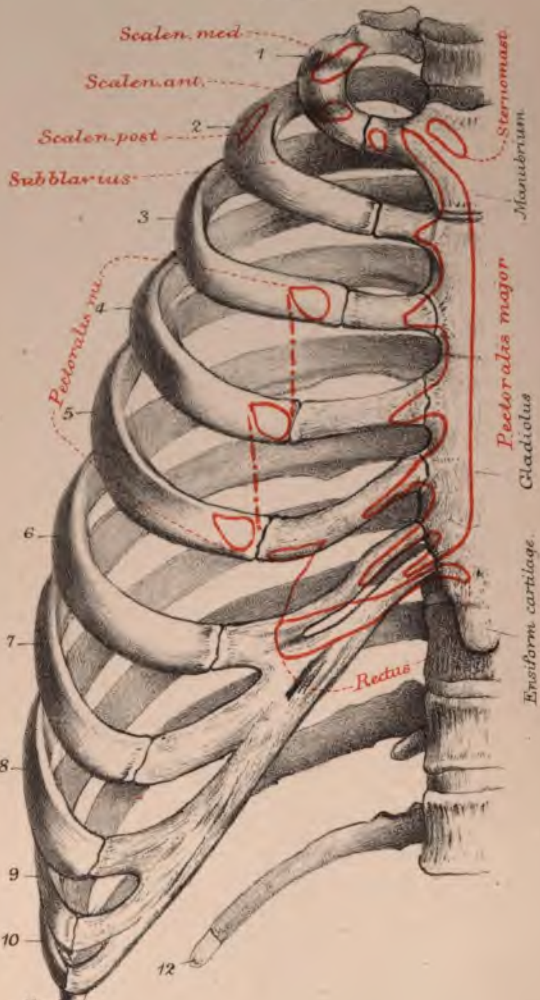
Cervical Vertebra, showing rotation round an oblique axis.

directions adds to the grace of movement for which the neck is peculiar.

Lateral flexion.—This is permitted in all regions.

THORAX

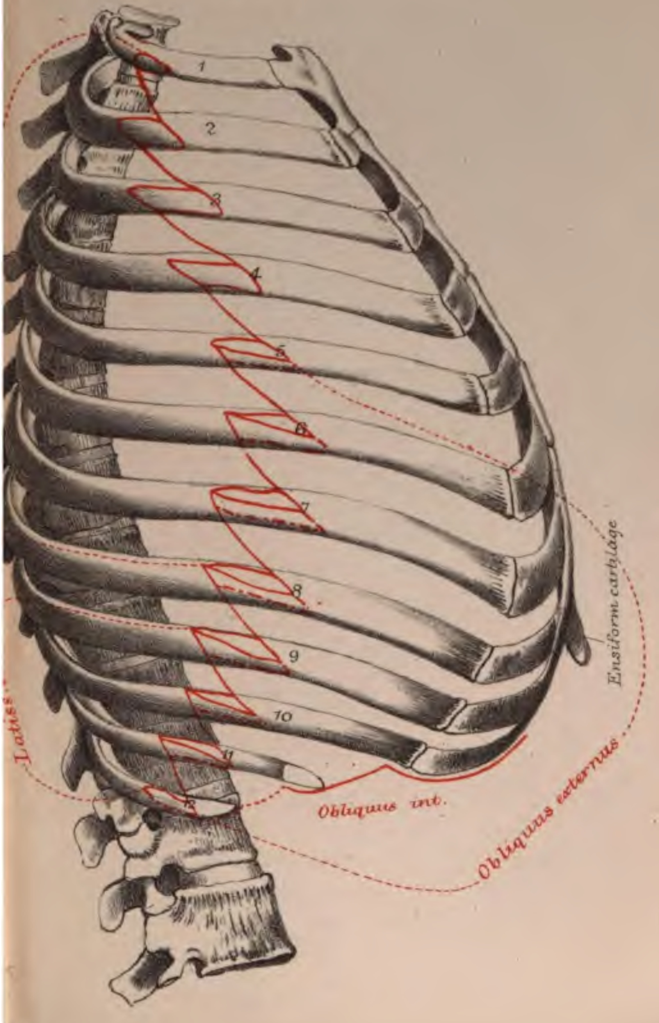
FRONT VIEW.



t side)

PLATE XI.

SIDE VIEW.



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THORAX.—Plate XI.

Synonyms : *E.* Chest. *G.* Der Brustkorb. *Fr.* La poitrine.

The bones which help to form the thorax are the sternum in front, the ribs on the sides, and the dorsal vertebræ behind. The cavity thus enclosed is a cone open above and below, the upper opening being naturally closed by a very large number of structures which are passing into and out of it, the lower being closed by the diaphragm, and the spaces between the ribs being filled up by muscles.

STERNUM.—Plates III.–XI.

Synonyms : *E.* Breast-bone. *G.* Brustbein. *Fr.* Le sternum.

The sternum occupies the front of the chest, and supports the inner ends of the clavicles. Seven of the costal cartilages are connected directly with it on each side. The upper end lies only a short distance (not 2 inches) in front of the spine, the lower projects considerably, so that the bone is obliquely placed; this obliquity is increased during inspiration.

Shape.—It has been likened to a sword, the upper broad part being the handle (manubrium), the middle the blade (gladiolus), and appended to the latter is a small point (ensiform cartilage).

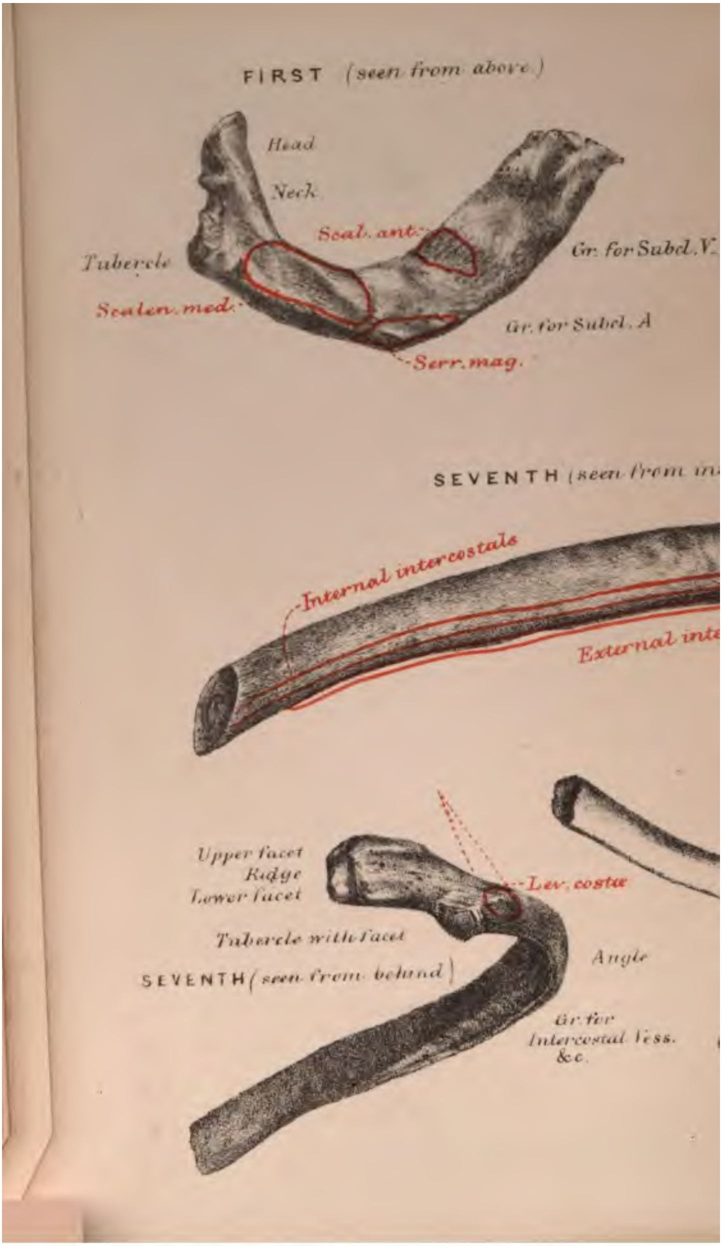
Parts.—The bone really consists of several coalesced segments, the number varying in different cases, but usually there are at least six; of these the manubrium is the first, the gladiolus represents the next four, and the ensiform cartilage one. These are seen in the development of the bone.

Manubrium, broad above, its *upper border* presenting three notches, the outer two being for the articulation of the clavicle and placed rather posteriorly, the middle constituting the inter-clavicular notch. *Lower border* presents an articular surface for the gladiolus. *Lateral border* marked by an oval articular surface above for the first costal cartilage and a half-facet below for the second. *Anterior surface* convex, rough for muscles. *Posterior surface* concave, smooth.

Gladiolus broader above than below, longer and narrower than the manubrium. *Anterior surface* marked by three or four ridges, indicating the original separation between the pieces; sometimes perforated by a foramen, the sternal foramen. *Lateral borders* showing a large rough half-facet above for the second costal cartilage and five whole facets below for the remaining true ribs; the upper three of these correspond with the transverse ridges on the bone. The *upper and lower* borders present articular surfaces for the manubrium and ensiform cartilage respectively.

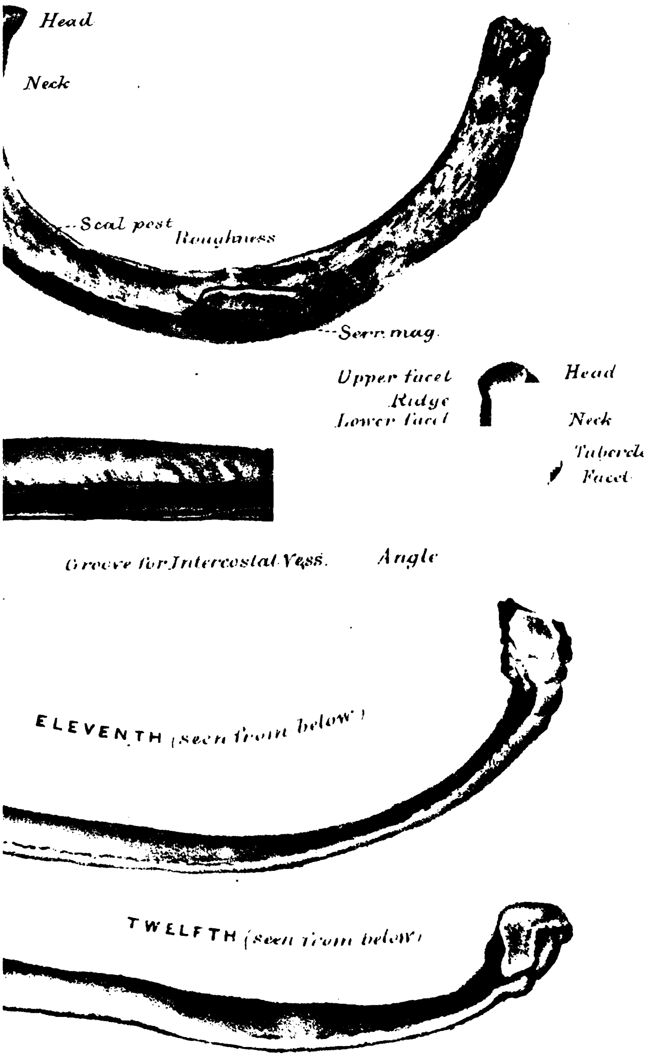
Ensiform or **Xiphoid cartilage** is cartilaginous until late in life, is thin and leaf-like, but sometimes bifid or perforated by a large hole.

Development.—From several centres, usually one for each segment, but sometimes two or more instead of one. Those for the upper segment appear about the 6th or 7th month of fœtal life, the other segments later; that for the fifth piece about the 1st year, that for the ensiform cartilage much later, 15 years, or later still. The lower segments unite after puberty, the upper segments about 25, the body and ensiform in middle age, the body and manubrium in old age.



FIRST (seen from above)
Head
Neck
Scal. ant.
Gr. for Subcl. V.
Tubercle
Scalen. med.
Gr. for Subcl. A
Serr. mag.
SEVENTH (seen from in
Internal intercostals
External inte
Upper facet
Ridge
Lower facet
Lev. costæ
Tubercle with facet
Angle
SEVENTH (seen from behind)
Gr. for
Intercostal Vess.
&c.

PLATE XIII.


SECOND (seen from above.)
Head
Neck
Scal. post
Roughness
Serr. mag.
Upper facet
Ridge
Lower facet
Head
Neck
Tubercle
Facet
Groove for Intercostal Vess.
Angle
ELEVENTH (seen from below)
TWELFTH (seen from below)

RIBS.—PLATES XI., XII., XIII.

Synonyms: *G.* **Die Rippen.** *Fr.* **Les Côtes.** *L.* **Costæ.**

Situation.—They occupy the greater part of the wall of the thorax, are twelve in number on each side, and are attached to the dorsal vertebræ behind in a peculiar manner: they each articulate usually with two adjoining bodies and intervertebral substances, and also with the transverse process of one vertebra. The upper seven of them are called **true or vertebro-sternal ribs,** as their anterior continuations, *costal cartilages,* are connected directly with the sternum; the next three **(vertebro-costal)** are connected each with the costal cartilage above; the last two are free and are called the **floating** or **vertebral ribs,** each being tipped with a costal cartilage.

Shape.—Each rib is a flattened curved band of bone, and curved peculiarly, so that (except in the case of the first two) the bone will not lie flat: one curve is directed with the concavity inwards, a second upwards seen towards the back of the bone, a third downwards seen in the anterior part, especially in those ribs between the 6th and the 10th. The upper ribs run nearly horizontally, the lower ones obliquely downwards and forwards, the 9th being most oblique. They increase in length from the 1st to the 7th, and then gradually diminish again. They are broader in front than behind, and decrease in breadth from the 1st to the 12th. They are separated by spaces (*intercostal spaces*) which are occupied by muscles.

Parts.—Each rib possesses a posterior extremity or

head, a constricted portion or *neck*, a rough prominence or *tubercle*, a sharp bend or *angle*, *a shaft*, and an anterior extremity.

Common characters:—

Head irregular, presenting two half-facets separated by a transverse ridge for the inter-articular ligament which connects it with an inter-vertebral disc.

Neck constricted, flattened, about one inch long, smooth in front and below, rough behind for the middle costo-transverse ligament, rough above for the anterior costo-transverse ligament.

Tubercle situated nearer the lower edge between the neck and the shaft, smooth and articular below for contact with the transverse process, rough above and behind for the posterior costo-transverse ligament. The tubercle is more prominent in the upper than in the lower ribs.

Shaft thin, flat, curved on itself and bent rather sharply, a short distance from the tubercle where it forms the **angle**, which increases in distance from the tubercle from the first to the ninth rib. *Outer surface*, convex, smooth, marked at the angle by an oblique line running downwards and outwards for the tendon of the *sacro-lumbalis M. Inner surface* smooth, concave, marked in its lower half by a distinct longitudinal groove, which is seen best towards the back of the bone; this is for the intercostal vessels and nerves. *Lower border* sharp. *Upper border* rounded.

Characters of special ribs.—Certain of the ribs differ from the others and can be distinguished by peculiar characters. These are the 1st, 2nd, 10th, 11th, and 12th.

First rib short, broad, flat and will lie on a level

surface. *Head* small and possesses a single articular facet for the first dorsal vertebra. *Neck* round, slender. *Shaft* flat, marked on its upper surface by (*a*) a rough surface near the tubercle for the *scalenus medius M.*; (*b*) a shallow groove in front of this for the *subclavian artery*; (*c*) a rough surface further forwards for the *scalenus anticus M.*; the outer extremity of this roughness is sometimes raised into a tubercle; (*d*) in front of this is another shallow groove for the subclavian vein. The anterior extremity is thick. The bone possesses no angle distinguished from the tubercle.

Second rib rather flat, and will usually lie on a level surface. *Shaft*, upper surface has a well marked roughness about the middle for the *scalenus posticus M.* This bone possesses an ill-marked angle, but the head has two half-facets.

Tenth rib. *Head* presents a single articular facet for the body of the 10th dorsal vertebra.

Eleventh rib, short. *Head* possesses a single articular facet. *Tubercle* absent, or if present it has no facet on it. *Angle* absent. No groove on the inner surface.

Twelfth rib, like the eleventh, but shorter.

Development.—From three centres—one primary for the shaft seen in the 7th or 8th week of fœtal life; two secondary ones for the head and one for the tubercle, seen about the 15th year; but in the case of the last two ribs, no epiphysis for a tubercle is found. The primary and secondary centres unite as usual from the 20th to 25th year.

Mechanism of the Thorax.—The chief purpose of the thorax is the protection of the heart and lungs, two of the most important viscera of the body, but

the thorax combines with this protecting function the power of pumping air alternately into and out of the chest, and it forms a support for the upper limbs.

The pumping power results from the mobility and elasticity of the ribs, and exists only in certain animals. This power is greatly increased by the rise and fall of the diaphragm or floor, by which means the vertical capacity of the thorax is altered. The central part of this floor, however, is practically fixed, so that the heart which lies upon it is not disturbed by the movements of the lungs, and is not capable of displacement by the different movements of the body. When the arms are being forcibly used the thorax is fixed; a deep breath is taken and held until the arms have done their duty, when the air is forcibly expelled; or another breath is hurriedly taken to replace the used-up air, and to enable the man to continue his efforts.

If we examine an articulated thorax we find the three curves already referred to in the ribs, and notice that the movements are peculiar. The head of the rib is fixed by ligaments to the spine, and motion occurs round this point. Again the anterior end of the costal cartilage is fixed to the sternum, and motion occurs round this point. Consequently one set of movements is round an axis which is the line joining these two points. Now the ribs are placed as oblique loops or arcs, the middle being lower than each end, consequently this movement necessitates a rising of the middle by a process of eversion, just as when the bent elbows are raised while the hands and shoulders are kept fixed on nearly the same level. With this movement, which is the means of greatly widening the chest, there

must necessarily be a gliding of the tubercle upon the transverse process, but this is very small in amount, since the tubercle is placed so near to one of the centres of rotation.

But there is another and a different movement. The anterior end of the costal cartilage is lower than the head of the rib, and provision is made for raising this in inspiration, and with its rise it is naturally pushed forwards and the sternum with it, so that the depth of the chest from before backwards is increased by this simple means. Now the greater the obliquity of the rib, the greater the extent of forward movement, and it will be seen that the lower ribs are most oblique, and each is more oblique than the one above, so that the lower end of the sternum is protruded more than the upper in inspiration.

Another kind of movement is to be found in the costal cartilages, which are here placed apparently with a special view to providing elasticity. They are somewhat closely connected to the sternum and ribs, and each rise and eversion and protrusion of the rib necessitates a twisting of these elastic cartilages. When the muscular action which has produced this has ceased, the elastic recoil of these cartilages is one of the only two or three simple means which eject the air in an ordinary expiration. The weight of the parts, and the elasticity of the lungs themselves form the other two factors.

It has been stated that the first rib is fixed, but observation shows that it rises in ordinary, and to a very marked extent in extraordinary inspiration.

It is out of place here to enter into the question of what muscles bring about these movements, but it

may be useful to summarize the latest observations, which are in some measure contrary to what has been previously accepted. In the Proceedings of the Royal Society, 1872, Mr. Le Gros Clark shows that:—

1. The normal state of the diaphragm, when at rest, is that of arched tension; and this condition is due to the elasticity of the lungs resisting the atmospheric pressure on its thoracic surface.

2. This tension is such that the diaphragm cannot be forced upwards whilst the ribs are fixed; and is exerted in drawing the ribs inwards when the intercostal muscles are relaxed.

3. The results due to this passive tension are that (*a*) it retains the supplemental air in the lungs; (*b*) it limits the encroachment of the abdominal viscera on the thoracic cavity; (*c*) by virtue of the attachment of the pericardium to the cordiform tendon, the uniform calibre of this bag is secured, and the heart is thus protected from being impeded in its movements during respiration, the crura taking part in maintaining this condition when the muscle contracts; (*d*) it economizes active power in inspiration.

4. *Inspiration.*—When the upper ribs are fixed by the scaleni, both sets of intercostal muscles act in increasing the transverse diameter of the chest, by raising the curve of the ribs and the sternum.

They rotate the ribs outwards.

They fix the thoracic walls, and thus antagonize the tendency of the diaphragm to draw inwards the ribs to which it is attached. A fixed circumference is thereby secured, from which the diaphragm acts in altering its own form; and this is one of the most important functions of the intercostal muscles.

They assist in expiration when the lowest ribs are fixed by the abdominal muscles.

5. The scalenus anticus and posticus (especially the former) are auxiliaries in inspiration by raising and fixing the first and second ribs, and thus rendering them relatively immovable.

Thus, when the scaleni act, the intercostal muscles raise the ribs; when the scaleni are at rest, and the abdominal muscles act, the intercostals depress the ribs; if neither the scaleni nor abdominal muscles were to act, the ribs would be approximated at their centre by the action of the intercostal muscles.

6. The pectoralis minor (when the coracoid process is fixed), the lower costal portion of the pectoralis major, and some other muscles of minor importance might assist in elevating the ribs; but it is questionable whether they ever do so in such way as to assist in inspiration.

7. The serratus magnus has no action in inspiration; all but its lowest digitation must draw the ribs downwards, if they act on them at all.

8. The action which the sterno-mastoid is capable of exerting in inspiration is by fixing the first rib through the medium of the clavicle, and by raising the sternum. This is not required in health, but may be witnessed occasionally in disease.

9. *Expiration.*—Ordinary expiration is accomplished by the elastic resiliency of the lungs, the tense diaphragm resuming its arched form when the muscle ceases to contract: the elasticity of the ribs and abdominal parietes may assist to a limited extent; after a deep inspiration this elasticity has a more important share in expiration. The abdominal muscles, which, conjointly with the levator ani, are the agents of forced expiration, do not act by urging the abdominal

viscera against the *tense* diaphragm, which would resist the pressure, to the injury of these viscera, but against the *relaxed* diaphragm—relaxed, that is, by the abdominal muscles drawing down the lower ribs, and thus contracting the circumference of the lower part of the chest.

The intercostal muscles also contribute importantly to this result, as the effect of their contraction is reversed, by the lower ribs being relatively fixed during the action of the abdominal muscles. In this way both the long diameter and circumference of the chest are abridged.

10. The upper and lower costal movements in both sexes, when entirely unfettered, are equal, in ordinary inspiration and in the uncontracted chest.

The costal movements, both upper and lower, are much greater in forced inspiration in the male than in the female.

In both, the lower costal movements are much abridged by compression of the abdomen and lower part of the chest, while the upper costal movements are exaggerated.

The observed fact that women breathe more by the chest than by the abdomen is due to artificial compression, and to the altered form of the chest consequent on its early adoption.

Distribution of force applied vertically through the skeleton.—It will be useful to look at the skeleton as a whole, and consider briefly some of its mechanical advantages. It would occupy too much space to enter into the mechanism of its various movements, but it is within the scope of this work to consider the skeleton in its ordinary erect position, and

observe the advantages gained by its peculiar construction (Fig. 62).

In standing the weight of the body is supported by the longitudinal arch of the foot, whose hinder end is a single bone, the os calcis, and whose fore end is spread out by the overlying weight so as to bring the heads of all the metatarsal bones into play, the first

Fig. 62.

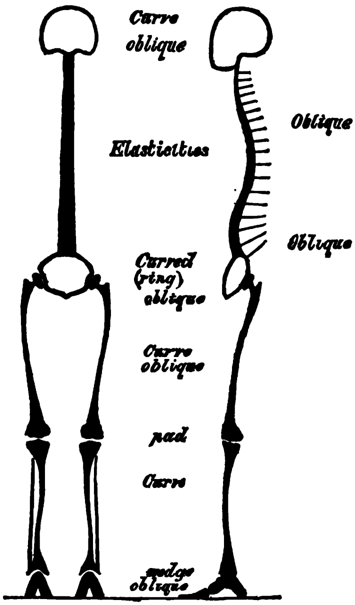


Diagram showing how force is broken in the erect position by curves, obliquities, and elastic media.

one being protected by its sesamoid bones. The arch is peculiar, and constructed so as to diffuse the weight

(p. 147), as already explained. The head of the astragalus is jammed in between the os calcis and the scaphoid and rests upon the strong calcaneo-scaphoid ligament, upon which it rotates, so as to spread the toes. The arch is tied from one end to the other by a strong band, the plantar fascia, which stretches immediately under the skin from heel to toes, and materially helps to preserve the shape of the foot; for if this ligament is weakened, as in flat-foot, the arch is destroyed, and the inner side of the foot comes down to the ground.

We must not omit to notice also the other arches in the foot, and the obliquity of the joints in the tarsus, nor must we lose sight of the protection which the thick pad of fat and skin affords to the bony prominences. It does not matter whether we trace the pressure downwards from the vertex, or the equal opposing pressure upwards from the ground to the vertex, but it is more convenient to follow the latter plan. We notice next, after the curves and obliquities of the foot, that the astragalus is wedged in between the two malleoli; force is here distributed. It is then traceable through the tibia, which is seen to be curved with its concavity outwards, and this bow is strengthened by the thin tie-rod which the fibula constitutes. Moreover, the tibia is spirally twisted, and this spiral adds to its strength and elasticity.

At the knee-joint the surfaces, besides being covered, as at the ankle and tarsal joints, by elastic cartilage, are further protected from injury by washers in the form of two loose semilunar fibro-cartilages. The obliquity of the shaft of the femur breaks the force of concussion, and the curved

surface, and general bowing of the bone add to its elasticity. Moreover, there is a distinct curve of its inner border, which constitutes a hitherto unnoticed feature in the mechanism of this bone, and practically does away with the weakness which the obliquity of the neck seems to allow.

Then at the hip-joint the direction of impact is doubly oblique, for in addition to that seen in front view there is a direction of the neck forwards, which insures a further dispersion of shocks. The head of the femur fits in a cup which is part of a strong obliquely placed ring, and we find, therefore, at this part, peculiar provisions against the effect of vertical pressure. The ring giving elasticity and protecting the important contents is formed by the thick brim of the pelvis, and is completed behind by the promontory of the sacrum; and it is placed obliquely at an angle of about 50° to the horizontal, so that the pressure upwards tends to bring this oblique ring nearer the horizontal, and in so doing breaks the violence of concussion. Moreover, this ring is a jointed one, and each joint still further breaks the force of pressure, and a curious and special provision is found at the joints between the sacrum and innominate to prevent a separation of the parts of this ring by the triple wedge-arrangement seen on transverse section (p. 170).

Passing further upwards we notice the obliquity of the sacro-lumbar joint, which is an example of the inclined plane, and next we notice in the spinal column special provisions for the protection of the spinal cord and the brain above. These include the three curves—lumbar, dorsal, and cervical; the number of separate bones, each with a different degree of

obliquity from those above and below; and the large amount of elastic intervertebral substance.

At the joint between the atlas and skull we find a double obliquity together with the cup-joints which allow of so great freedom of motion.

And lastly, the shape of the vault of the cranium protects it from injury, since it is curved in outline and, as we shall see, strengthened by groins and arches in its interior. Moreover, the middle line of the base of the skull is an elastic lever, which gives further protection.

We must not omit the further mechanical arrangement which we have noticed in the internal architecture of each of the bones: a delicate and beautiful arrangement which excites our wonder and admiration —chiefly on account of its adaptation to the wants of each bone and its protecting influence against injury.

This brief outline of the mechanism of the skeleton in the erect position will give some idea of the wonderful bony framework on which we are built, and will lead us to see, in the otherwise dry and uninteresting study of Osteology, a subject full of the most interesting materials.

BONES OF THE SKULL.

These are usually divided for the convenience of description into cranial and facial bones, the former consisting of those which enter into the composition of the brain-case, and the latter of those which appear in the face. The cranial bones are eight in number—frontal, two parietal, occipital, sphenoid, two temporal, and one ethmoid—but in the adult the occipital and sphenoid are united. The facial bones are more numerous, but smaller; they are usually reckoned as fourteen in number—two superior maxillary, two palate, two malar, two nasal, two lachrymal, one inferior maxillary, one vomer, and two inferior turbinated; but to these may be added the two sphenoidal turbinated bones, the eight ear bones, and lastly the hyoid, as it belongs developmentally to the skull.

In the description of the bones of the skull it will be unnecessary to refer to the mechanism of each bone separately, as they together form a solid case, whose mechanical features are dependent upon the union of the whole.

CRANIAL BONES.

FRONTAL.—Plate XV.

Synonyms: ***E.*** **Forehead-bone.** ***G.*** **Das Stirnbein.** ***Fr.*** **L'os frontale.** ***L.*** **Os frontis.**

Situation.—The frontal occupies the forehead and the greater part of the roof of the orbit.

Shape.—Resembling a cockle-shell.

Parts.—The portion which constitutes the forehead is called the vertical or frontal, that which overlies the orbit the horizontal or orbital plate.

Examining the bone as a single structure, we find an outer or fronto-orbital surface, an inner or cerebral surface, and a border.

Outer surface.—Vertical portion convex, smooth, covered by the *occipito-frontalis M.*, which wrinkles the skin of the forehead transversely, and limited below by a sharp edge which overhangs the orbits. Going from above downwards, we see

(1) The **frontal eminence**, the most projecting portion of the surface, and especially prominent in certain individuals in whom the brain is especially developed at this spot.

(2) A slightly raised arched eminence, the **supraciliary ridge**, corresponding with the eyebrows, and indicating the position of certain air-spaces in the bone called **frontal sinuses**.

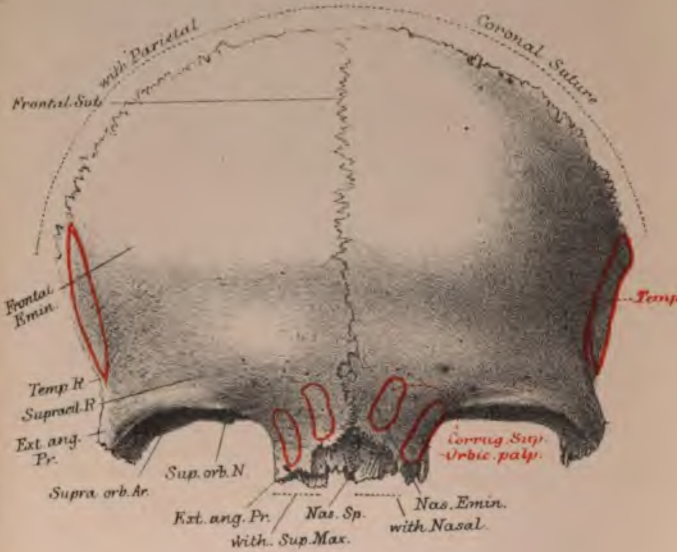
(3) A central eminence over the same cavities, but in the middle line, and called **nasal eminence**.

(4) The **supra-orbital arch** or edge between frontal and orbital portion.

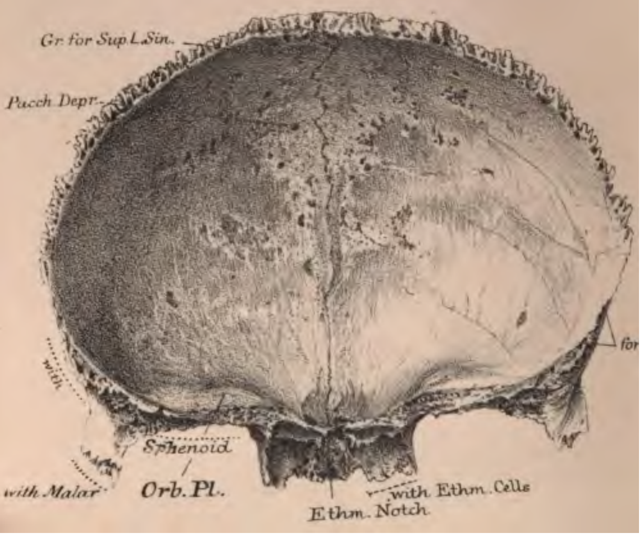
(5) The **supra-orbital notch** or **foramen** in the

FRONTAL

OUTER SURFACE.



INNER SURFACE



PARIETAL

PLATE XV

OUTER SURFACE

INNER SURFACE

& Cº lith.

inner third of this arch, transmitting a nerve and vessels of that name to the skin of the forehead.

(6) The **internal angular process** or prominent angle on the inner side of the orbit for articulation with the superior maxilla.

(7) **Nasal spine,** the median rough spine to which the nasal bones are articulated in the centre of the

(8) **Nasal notch,** a triangular gap in the bone.

(9) On the outer extreme of the supra-orbital arch is the **external angular process** for articulation with the malar bone, and running upwards and backwards from this is

(10) The **temporal ridge,** to which the temporal fascia is fixed, and below which the bone is rough for the *temporal muscle.*

(11) Sometimes in the middle line of the bone is seen a suture (**frontal suture**), indicating the original separation of the two halves of the bone, but this suture is not commonly present, or it is only just indicated above the nasal notch.

Horizontal portion consists of two orbital plates and an intervening notch. The plates are concave, especially near the angular processes, and are narrow behind but broad in front. Tracing from the outer extreme we find

(1) **External angular process** forming the outer angle.

(2) A depression near to the latter (**lachrymal fossa**), for the lachrymal gland.

(3) A depression near the internal angular process (**fovea trochlearis**), or a small spine for the fibrous pulley through which runs the tendon of the *superior oblique M.* of the eye.

(4) **Internal angular process,** forming the inner projecting angle.

(5) A large cavity running into the nasal eminence and supraciliary ridge (**frontal sinus** or **cell**).

(6) Several shallow imperfect cavities which close in the upper ethmoidal cells in the natural state, and bound the notch between the two orbital plates.

(7) One or two grooves or canals running obliquely between the cells, and forming parts of the **anterior and posterior ethmoidal foramina,** the anterior transmitting the nasal nerve, and each carrying vessels.

(8) The **ethmoidal notch** or gap between the two orbital plates. This is sometimes closed in by a thin scale of bone posteriorly.

Internal or cerebral surface. The separation between vertical and horizontal portions is not so distinct as externally. On this surface can be distinguished

(1) Numerous small depressions for the convolutions of the brain.

(2) Small depressions irregularly arranged on either side of the middle line, for so-called *Pacchionian bodies.* They are absent from young and healthy skulls, and probably represent the result of slight disease, of so many headaches so to speak.

(3) A median shallow groove, for the superior longitudinal sinus, broad above, narrowed to a mere line, or to a foramen (**the foramen cæcum**) below.

(4) The orbital plates, convex and irregularly sinuous for the supra-orbital convolutions.

(5) The ethmoidal notch.

The border is curiously arranged for locking in both the parietal bones, for at the highest point the inner edge is bevelled; towards the lower part of the frontal portion the outer edge is bevelled; and at the junction of the vertical and horizontal portions the articular edge is greatly prolonged on the outer surface, and here comes in apposition with the great wing of the sphenoid. On the back of the horizontal plate the edge is thin and sometimes smooth in the middle third of each plate, where it may form the free border between the anterior and middle fossæ in the base of the skull; in such cases the great and lesser wings of the sphenoid are widely separated. The ethmoidal notch is seen on this border in the middle line.

Articulations.—With 12 bones: 2 being median—viz., sphenoid and ethmoid; 5 in pairs—viz., parietal, nasal, superior maxillary, lachrymal, and molar.

Development.—From 2 centres—the two halves sometimes remaining distinct. They are first seen above the orbit in the 7th week, and generally unite in the 2nd year.

Points of importance:—

1. Specially marked frontal eminences.

2. Peculiar hollow air-spaces or frontal sinuses. These do not appear until nearly the age of puberty, and vary much in different persons. They communicate with the nostrils and are lined with the same mucous membrane, and when inflamed, as in a severe influenza cold, are sometimes the seat of much pain. Their communication with the nose accounts also for the occasional instances of larvæ, &c. being blown from the nose, and also of air escaping under the skin of the forehead.

3. Thin orbital plates or roofs of the orbits. A punctured wound of the orbit may be attended with perforation of this plate and injury to the brain; and a fracture of the base of the skull through this plate is evidenced by bleeding into the orbit, and usually above or around the globe of the eye.

PARIETAL.—Plate XV.

Synonyms: *E.* Synciput, wall-bone. *G.* Das Scheitelbein, Seitenbein. *Fr.* Le pariétal. *L.* Os parietale.

Situation.—One on each side of the vault, the two together forming a beautiful arch for the protection of the brain.

Shape.—Each is a four-sided plate, hollowed out chiefly from above downwards, the thin prominent angle being anterior and inferior.

Parts.—Outer surface, inner surface, four borders, and four angles.

Outer surface convex, smooth in its upper three-fourths, where it is covered by the occipito-frontalis, marked by a curved line in its lower fourth (**temporal ridge**) for the temporal fascia, below which the surface forms part of the temporal fossa, and is marked by lines converging below: this part gives attachment to the *temporal M.* Near the upper border are seen one or two **parietal foramina**, for small veins entering the longitudinal sinus. The most prominent point of this surface is called the **parietal eminence.**

Inner surface smooth, concave, marked by shallow depressions for the cerebral convolutions, by numerous deep small grooves for the *middle meningeal artery*, which are radiating from the anterior inferior angle, by a half-groove along the upper border, which is completed when the two parietal bones are articulated together, and then lodges the *superior longitudinal sinus;* by numerous irregular depressions along the

side of the latter groove, for Pacchionian bodies, and by a large rather deep groove for the lateral sinus running across the posterior inferior angle. Sometimes the inner openings of the parietal foramina are seen in the groove for the superior longitudinal sinus.

Borders. Upper thick, deeply serrated, entering into the sagittal or inter-parietal suture, sometimes perforated by parietal foramina; it is marked on its inner surface by a groove for the longitudinal sinus. *Lower* thin, much bevelled on outer side, entering into the squamous or temporo-parietal and the spheno-parietal sutures. *Anterior*, bevelled at the expense of the outer surface above, of the inner surface below. *Posterior* deeply dentated, thick, often presenting numerous separate intersutural bones (**Wormian, ossa triquetra**); it articulates with the occipital and mastoid part of the temporal bone, and enters into the lambdoidal suture.

Angles. Anterior superior, nearly a right angle; its anterior border is bevelled at the expense of the outer surface, and not deeply dentated; its inner border is deeply dentated, and marked by Pacchionian depressions, and only a slight half-groove.

Anterior inferior very prominent, acute, thin, marked on the inner side by grooves for the middle meningeal artery.

Posterior inferior very rounded, thick, marked on its inner surface by a groove for the lateral sinus, and not infrequently possessing an intersutural bone in place of the angle.

Posterior superior obtuse, thick, marked on its inner surface by a half-groove for the longitudinal sinus along its upper edge; the posterior border is very

deeply dentated, and possesses often intersutural bones.

Articulations.—With 5 bones—viz., the opposite parietal, sphenoid, frontal, temporal, and occipital.

Development.—From a single nucleus; generally first seen about the parietal eminence in the 7th or 8th week of fœtal life.

Means of distinguishing right from left.—Hold as if in your own head with the thick serrated edge towards the middle line, the convex surface outwards, and the thin squamous edge downwards; the most acute of the lower angles points forwards and to the side to which the bone belongs.

Points of importance :—

1. Peculiar characters of each angle.
2. Provision for overlapping in the fœtus.

OCCIPITAL.—Plate XVI.

Synonyms : *E.* Nowle bone. *G.* Das Hinterhauptsbein. *Fr.* L'occipitale. *L.* Os occipitis.

Situation.—The occipital occupies the back and part of the base of the skull, and rests upon the upper end of the spinal column. It forms one bone with the sphenoid in the adult, but is usually separated by sawing through the basilar process which unites them.

Shape.—Irregularly four-sided, forming a concave plate perforated near its anterior angle by a large oval hole—the foramen magnum.

Parts.—Two surfaces, four borders, and four angles.

Exterior surface convex, marked by (1) a curved line, **superior curved line,** halfway between the summit and the large foramen magnum, stretching across the bone from one angle to the other, and giving attachment to muscles.

(2) Above this line a smooth convex surface, over which the aponeurosis of the *occipito-frontalis M.* glides.

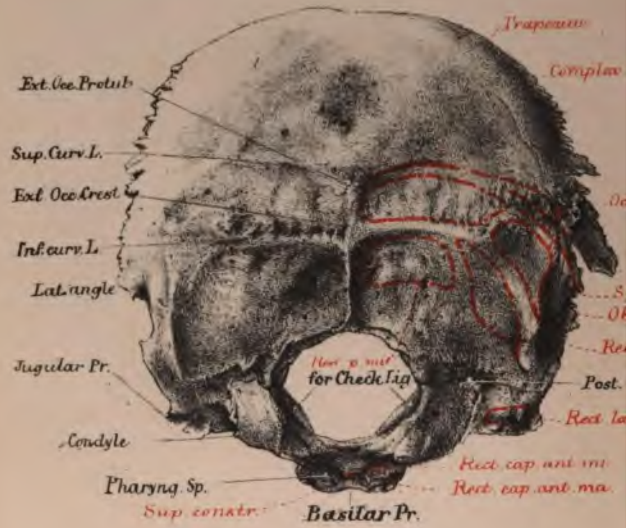
(3) In the middle of the line is a prominent tubercle, the **exterior occipital protuberance,** for the attachment of the *ligamentum nuchæ*, a ligament which in most animals is of great strength, to support the weight of the head.

(4) Running from this downwards, to the foramen magnum, is a median ridge, the **exterior occipital crest,** also for the *ligamentum nuchæ.*

(5) Halfway between the superior curved line and

OCC

OUTER VIEW



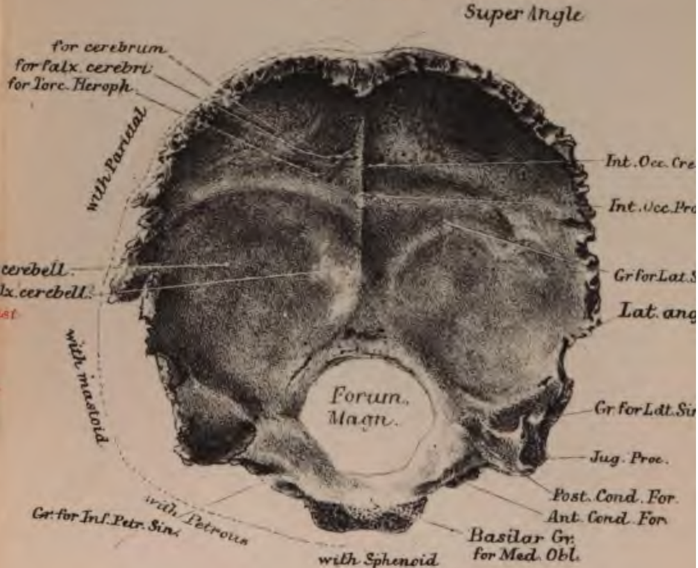
SPH

BACK VIEW

AL BONE (RIGHT)

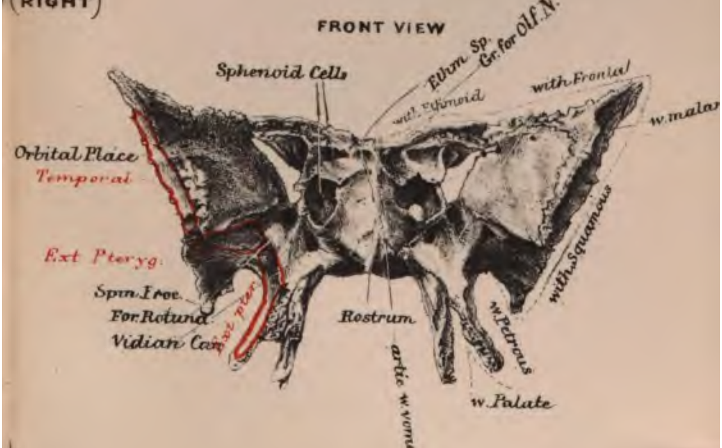
PLATE XVI

INNER VIEW



(RIGHT)

FRONT VIEW



& C° Lith.

the foramen magnum is another line, the **inferior curved line,** also for the attachment of muscles. It ends at a projection on the border of the bone called the **jugular process.**

(6) The **foramen magnum** is the large oval hole in the bone below, and transmits the spinal cord and its membranes, spinal accessory nerve, vertebral arteries, and a large plexus of veins.

(7) On each side of the anterior half of the foramen are the **condyles,** which are oval, convex, articular processes, with their long axes converging anteriorly, so that if produced they would meet about an inch in front of the foramen magnum.

(8) A depression behind each condyle, with sometimes a foramen (**posterior condyloid foramen**) for a vein passing into the lateral sinus.

(9) A large foramen in front of each condyle (**anterior condyloid foramen**), for the hypoglossal or ninth cranial nerve to pass out of the cranium.

(10) Outside each condyle is a rough surface for the *Rectus lateralis M.*, on an irregular projection, the **jugular process.**

(11) The **basilar process** is the continuation of the bone forward into the sphenoid, and on it is seen

(12) A small tubercle, the **pharyngeal spine,** in the middle line for the attachment of the aponeurosis of the *superior constrictor M. of the pharynx.*

The *inner surface* is concave and presents

(1) A large groove for the *superior longitudinal sinus*, running from the summit to

(2) The **interior occipital protuberance,** which corresponds with the exterior protuberance, and is one of the strongest parts of the bone.

(3) Running across the bone from this central

point are two deep grooves for the *lateral sinuses*, one on each side to about the external angles, the right groove being usually the larger, and more directly continuous with that for the superior longitudinal sinus. The three grooves meet on the right side of the protuberance, where a kind of vortex is produced in the venous sinuses (**Torcular Herophili**).*

(4) A median ridge running downwards to the foramen magnum and called the **interior occipital** crest. It gives attachment to the *falx minor*, a fold of dura mater slightly separating the two halves of the cerebellum, and is sometimes grooved on one or both sides for the occipital sinuses.

(5) The **foramen magnum** with (6) the inner opening of the **anterior condyloid foramina** in the edge of the foramen.

(7) The basilar process with the **basilar groove** in the middle line, on which lies the *medulla oblongata*.

(8) On the edge of this process is a half-groove for the *inferior petrosal sinus*, traceable backwards to

(9) A deep groove for the *lateral sinus* which runs over a projecting portion of the edge, called the jugular process; in this position is also seen the inner opening of the posterior condyloid foramen.

Borders.—The two sides are alike, and are divided into an upper and lower part by the external angle. The upper is deeply serrated; the lower is irregular but not serrated, and about midway along it is the projecting **jugular process**, over which the groove for the lateral sinus passes, forming a depression in the border in front of it called the **jugular fossa**.

* Named after Herophilus, an anatomist of the days of *Ptolemy* Soter, 323–285 B.C.

This fossa is converted into a foramen (called the jugular foramen or posterior lacerated foramen) by the temporal bone and transmits the *jugular vein* and the eighth pair of nerves. A spicule of bone in the front of this notch sometimes produces a second or even a third foramen when the bones are articulated, and the latter two transmit the portions of the eighth pair of nerves: the *pneumogastric* and *spinal accessory* in the posterior, the *glosso-pharyngeal* alone in the anterior or inner foramen. Along this border is seen the half-groove for the inferior petrosal sinus.

Angles.—*Upper* angle or summit pointed, forming the apex of the lambdoidal suture. *Lower* formed by the basilar process. *Outer* obtuse, fitting in between the mastoid and parietal.

Articulations.—With six bones: sphenoid, atlas, two temporal and two parietal.

Development.—From four centres, each seen about the 7th or 8th week of fœtal life. They are for the basilar portion, the two condyles, and the tabular or ascending portion, in which, however, sometimes four nuclei are found. Occasionally separate centres are seen in the upper angle and each lateral angle.

Points of importance:—

1. Peculiar shape, fusion with the sphenoid into one bone.

2. Perforated by foramen magnum, and marked by protuberances, curved lines, and crests, which nearly correspond on the exterior and interior.

3. It is the only bone which articulates with the spinal column.

4. Extreme thinness of the bone in the fossæ. Extreme thickness of the margin of the foramen magnum and basilar process.

As the head is supported at the condyles, it follows that a heavy blow on the top of the head, or a fall on the feet from a height, tends to drive the condyles into the brain. This is provided against by the strength of the occipital and sphenoid bones along certain lines (*vide* p. 264 and Figs. 64, 65), so that fracture of the base less commonly involves this bone than any other of the basal bones.

SPHENOID.—Plate XVI.

Synonyms: *E.* Wedge-bone. *G.* Das Wespenbein, Keilbein. *Fr.* Le sphénoïde. *L.* Os sphenoidale.

Situation.—Fitted in as a wedge in the middle of the base of the skull, and constituting nearly the whole of the middle fossa; articulating with all the other cranial bones, and fused into one bone with the occipital in the adult.

Shape.—Somewhat resembling a bat with its wings spread. The lateral expansions are called the great wings, and spring from the central part or body, while two double legs or pterygoid processes descend from the junction of the great wings and body.

Parts.—The central part or body is continued backwards into the basilar process, while from its front two small wings stretch outwards, one on each side. The great wings are the large lateral expansions, and the pterygoid processes project downwards.

The shape of the bone being so irregular, it is often examined in its separate parts, but these have no well-defined limit. It is therefore better to take the bone as a whole and examine six surfaces.

Upper surface. In or near the middle line from before backwards are seen on the body and lesser wings of the sphenoid :—

(1) A projecting process, the **ethmoidal spine,** which fits into the back of the ethmoid bone.

(2) A ridge running backwards from this and continuous with that on the ethmoid.

(3) A groove on either side of this ridge, **olfactory groove,** for the olfactory lobe of the brain.

(4) Further outwards the plane upper surface of the **lesser wings** terminating posteriorly in

(5) The **anterior clinoid processes** to which the dura mater is attached: these processes lie behind

(6) The **optic foramen,** a circular hole passing through the roots of the lesser wing, and transmitting the optic nerve and ophthalmic artery into the orbit. From the foramen there can be traced

(7) The **optic groove** running towards the middle line, in which position is

(8) An eminence, **olivary eminence,** shaped somewhat like a small olive, and upon which the optic commissure lies. Behind this is

(9) The **sella turcica,** or **pituitary fossa,** a deep cavity, shaped like a Turkish saddle, and lodging the pituitary body; it is bounded behind by

(10) The **posterior clinoid processes,** two projecting processes which also give attachment to the dura mater.

(11) There is usually a small tubercle near the front part of the fossa, **middle clinoid process,** and not infrequently a process of bone runs from the anterior to the middle process thereby surrounding the carotid artery.

(12) On each side of the body is a well-marked groove for the *cavernous sinus,* traceable forwards to the posterior root of the lesser wing where it divides, indicating the course of the carotid artery upwards and of the ophthalmic vein backwards from the sphenoidal fissure; it is traceable backwards to a depression on the posterior border of the bone.

(13) The **basilar process** is the continuation of the bone backwards, and is marked by

(14) A shallow groove on each side for the *inferior petrosal sinus*, continuous with that for the cavernous sinus. Between the lesser and great wings we notice

(15) A large triangular aperture, **sphenoidal fissure,** or **anterior lacerated foramen,** generally closed above at the outer angle by the frontal bone, and transmitting the *3rd, 4th, 1st division of the 5th* and *the 6th nerves*, together with the large *ophthalmic vein.*

The great wing itself is noticed to be concave and marked by

(16) The **foramen rotundum** behind and external to the sphenoidal fissure, running directly forwards in the bodies and transmitting the *superior maxillary*, or *2nd division of the 5th nerve.* Behind and external to this again is

(17) The **foramen ovale,** a large hole running downwards in the bone and transmitting the *inferior maxillary, or 3rd division of the 5th nerve*, together with the *small meningeal artery.* Behind and external to this again is

(18) The **foramen spinosum,** a small foramen transmitting the *great meningeal artery* and running perpendicularly through

(19) The **spinous process** of the sphenoid, which is the posterior projection of the bone.

(20) On the inner side of the foramen rotundum is a small opening, **foramen Vesalii,** for a small vein, and named after Vesalius, a great anatomist, who deserved a better tribute to his memory.

Under surface limited by the temporo-zygomatic ridge on each side, and therefore including part of the great wing, pterygoid processes, and the body of the bone. Going from before backwards we notice—

(1) A projecting plate, the **rostrum,** which fits into the hollow of the vomer

(2) A cleft or groove for the alæ of the vomer, overlaid by

(3) The projecting edge of the root of the internal pterygoid plate named the **vaginal process.**

(4) Another groove or canal, **pterygo-palatine,** further on the internal pterygoid plate, and transmitting vessels and nerves of the same name.

(5) The two pterygoid plates with the pterygoid fissure between them.

(6) The basilar process.

(7) On the under surface of the great wing is seen the opening of the foramen ovale and

(8) Foramen spinosum, with

(9) The spinous process projecting often considerably downwards for the *internal lateral ligament* of the jaw, and *tensor palati M.*

(10) Temporo-zygomatic ridge separating the lower from the outer surface of the great wing, and indicating the separation between the *temporal* and *external pterygoid Ms.,* which occupy the temporal and zygomatic fossæ respectively.

Anterior surface is smaller than the upper, and occupies chiefly the back of the orbit. It presents

(1) A median projecting plate which fits into the back of the ethmoid, and on each side of this

(2) The hollow cavity of the body, **sphenoidal cells** or **sinuses,** which are partially closed in by small curved bones called sphenoidal turbinated bones.

(3) The **lesser wings** spreading over

(4) The **sphenoidal fissure,** and enclosing

(5) The **optic foramen** between the two roots. Around the margin of this foramen on this aspect are attached the muscles going to the globe of the eye (4 *recti superior oblique, levator palpebræ*).

(6) The anterior opening of the **foramen rotundum.**

(7) A smaller foramen (**vidian**) below, and internal to foramen rotundum, and immediately above the internal pterygoid plate. It gives passage to the *vidian nerve*, and

(8) The front surface of the great wing, **orbital plate,** a four-sided plate; articular along two borders, the upper for the frontal, the anterior for the malar bone; non-articular along two borders, the posterior forming a boundary to the sphenoidal fissure, the lower to the spheno-maxillary fissure; the plate is perforated by

(9) A few foramina (**external orbitar foramina**) for vessels.

(10) The pterygoid processes separated below by a cleft in which the palate bone fits.

Posterior surface. This includes the cut surface of the basilar process, and the pterygoid processes, together with the posterior border of the great wing. Besides

(1) The basilar process, and

(2) Posterior border of great wing, we notice

(3) A foramen above the internal pterygoid plate (**vidian foramen**).

(4) The **external pterygoid plate,** broader than the internal, everted below, giving attachment to the *external pterygoid M.* on its outer surface (and very slightly to the *internal pterygoid* also), and to the *internal pterygoid M.* on its inner surface.

(5) A notch between the two plates (**pterygoid notch**), filled up in the articulated skull by the palate bone.

(6) The **internal pterygoid plate** giving attachment in the lower third of its posterior margin to the *superior constrictor M.* of the pharynx, and ending in

(7) The **hamular process,** a little hook round which the tendon of the *circumflexus* or *tensor palati M.* runs. The upper third of this plate is hollowed out to form

(8) The **scaphoid fossa,** in which the *circumflexus palati* arises.

The outer surface consists of two parts separated by the under surface of the great wing. The upper part therefore belongs to the great wing, and is limited by the temporo-zygomatic ridge, and gives attachment to the *temporal M.;* the lower part belongs to the outer pterygoid plate, and attaches the *external pterygoid M.*, but a small portion at the lip is marked off for the *internal pterygoid M.*

Articulations.—With 12 bones: 4 being median—viz., ethmoid, frontal, occipital, and vomer; and 4 in pairs—viz., temporal, parietal, malar, palate.

Development.—From 10 centres—one for each great wing and external pterygoid plate, appearing about the 8th week; two for the back part of the body, about the same time; one for each internal pterygoid plate, about the 4th month; two for the anterior part of the body with the lesser wings, about the 8th or 9th week; one for each spongy bone about birth. The centres for the posterior part of the body unite in the 4th month, those for the pterygoid processes a little later, the anterior and posterior parts of the body about the 8th month, the body and great wings in the first year, and the sphenoidal spongy bones unite with the body usually about puberty.

Points of importance:—

1. Peculiar bat-like shape.
2. It articulates with all the cranial bones, and is wedged in between them.
3. It appears in both the anterior and middle fossa of the base, and in the orbital, temporal, zygomatic, spheno-maxillary, and pterygoid fossæ exteriorly.

It must be noticed that the sella turcica lies over the back of the fauces (Plate XXIII.), and that when fracture has taken place in the middle fossa across the sella—and this is the course which fractures of the base rather frequently follow—there will be escape of blood into the throat and mouth; part will probably be swallowed and afterwards vomited. It is evident therefore that after an injury to the head, bleeding from the mouth and nose and vomiting of blood are very serious symptoms, and may indicate fracture of the base of the skull. If the tongue be bitten the bleeding may arise from that source, but in such a case the tongue can usually be seen to have been lacerated.

TEMPORAL.—Plate XVII.

Synonyms: *E.* **Temple bone.** *G.* **Das Schläfenbein.** *Fr.* **L'os temporal.** *L.* **Os temporum.**

Situation.—At each side of the skull, running int the base, where it forms a strong buttress. Its posi tion varies slightly according to age, but in the adul skull the solid pyramidal part (petrous portion projects forwards and inwards, the thin portio (squamous) vertically upwards, and the hooked prc cess (zygoma) horizontally forwards.

Parts.—Certain parts are usually distinguishec They are:—

(*a*) The **squamous** or thin vertical portion, limite on its outer surface below by a line, the tempore ridge, and by the **zygoma,** which process belong developmentally to the squamous portion.

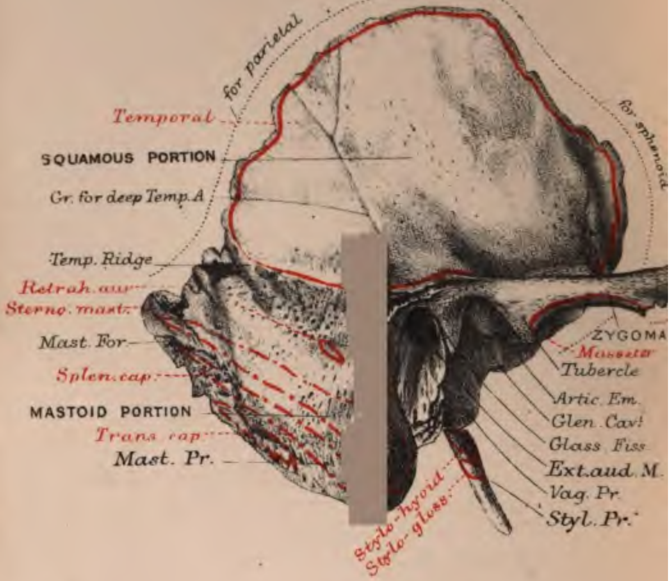
(*b*) The **petrous,** or strong pyramidal proces which projects inwards and forwards in the base (the skull. It is not very accurately limited, and portion of it is called the mastoid.

(*c*) The **mastoid,** because it forms a nipple-lik process behind the ear. It is, however, only the bas of the petrous portion, and is developed from th same centre of ossification.

Each of these parts* can be examined separatel but it will be better to take the bone as a whole, an examine three surfaces, outer, inner, and under, an its one border, the upper, since the under border : broad enough to constitute a surface.

* It will sometimes be convenient to call these portio squamosal and petrosal bones, the latter including the mastoi

TEMPORAL (*right*)
OUTER SURFACE.

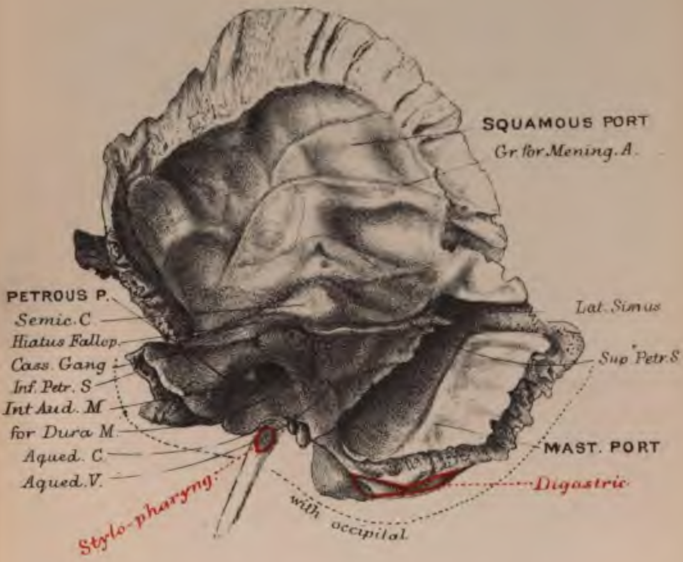


ETHMOID

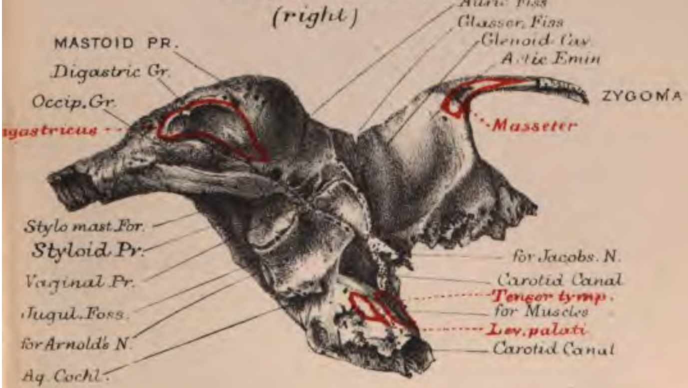
Seen from left side *Seen from behind*

PLATE XVII.

TEMPORAL (*right*)
INNER SURFACE.



UNDER SURFACE.
(*right*)



& C° lith

Outer surface. The *Squamous portion* is well defined by margin of bone above, by a horizontal line above the mastoid process (part of the Temporal Ridge), and by the base of the zygoma, or curved thin process which projects forwards about an inch from the bone. The surface is smooth (for *temporal M.*), and sometimes marked by small grooves by the deep temporal artery.

The **zygoma** is directed at first outwards, then is twisted on its own axis and directed forwards; its upper edge is sharp, and attaches the temporal fascia; its lower edge thicker, arched, and gives attachment to the *masseter M.*; outer surface convex, subcutaneous, inner surface concave, also for the *masseter M.*; extremity rough, bevelled at the expense of the lower edge, and articulates with the malar bone. Its connexion with the rest of the squamous portion is by three roots, (*a*) the anterior running directly inwards from a prominent **tubercle** (to which is attached the *external lateral ligament*), and forming a ridge (the **articular eminence**) in front of the articular cavity for the lower jaw; its posterior running backwards and dividing, the middle root (*b*) forming the anterior boundary to the external auditory meatus as far as a fissure (the **Glasserian**), and the posterior (*c*) continuing directly backwards above the meatus, and becoming the temporal ridge.

Mastoid portion rough, convex, gives attachment to three muscles, *sterno-mastoid*, *splenius capitis*, and *transversalis capitis* (otherwise called the *trachelo-mastoid*); perforated towards the posterior border by a foramen (the **mastoid foramen**) for a vein. The mastoid portion lies altogether behind the external auditory meatus, and its projecting process is called

the **mastoid process.** It is separated from the meatus by a fissure (the **auricular fissure**).

Petrous portion, only seen below and slightly in front of the external auditory meatus.

Inner surface. *Squamous portion* marked by depressions for the convolutions of the cerebrum, and by small grooves for the middle meningeal artery, which start from the angle of junction between the squamous and petrous portions in front. The articulating free edge of the bone is thin, owing to the greater part of the squamous or temporo-parietal suture involving this edge, and encroaching on its inner surface. The limit between squamous and petrous portions is not well defined.

Petrous portion projects inwards and forwards, and presents an upper (or anterior) and a posterior surface. On the upper are seen—

(*a*) Near the tip a shallow depression for the *Casserian ganglion.*

(*b*) A groove leading to a foramen (**Hiatus Fallopii**) for the *great superficial petrosal nerve.*

(*c*) Sometimes a small groove and foramen outside this for the *small superficial petrosal nerve*, but this at other times is replaced by a small foramen only, in the anterior border of the bone.

(*d*) A deficiency over a large canal (carotid canal) seen in the anterior border.

(*e*) An eminence indicating the position of the superior semicircular canal in the substance of the bone.

On the posterior surface are seen—

(*a*) Along the edge between the upper and posterior surfaces a groove for the *superior petrosal sinus*, ending in the deep groove for the *lateral sinus* on the mastoid portion.

(*b*) A half groove running downwards by the tip, for the *inferior petrosal sinus.*

(*c*) A large foramen (the **internal auditory meatus**), at the bottom of which can be seen a single large hole above for the *facial nerve*, and several small holes below for the *auditory nerve.*

(*d*) A cleft above and behind the internal auditory meatus for a process of dura mater.

(*e*) Another cleft behind and towards the lower edge for a vein in the **aqueductus vestibuli.**

Mastoid portion deeply grooved by the *lateral sinus* along the line of junction with petrous and squamous portions, and in this groove the inner opening of the mastoid foramen is usually visible.

Under Surface irregular. Belonging to the *squamous portion* are—

(*a*) Lower edge of zygoma.

(*b*) Tubercle of zygoma.

(*c*) Anterior root forming the **eminentia articularis.**

(*d*) Behind this a deep smooth cavity (the **glenoid cavity**) for the condyle of the lower jaw, bounded behind by

(*e*) A fissure (the **Glasserian**), in which lies the processus gracilis of the malleus and a muscle (*laxator tympani*).

Petrous portion presents immediately behind the Glasserian fissure

(*a*) A smooth plate of bone, which forms the anterior wall of the external auditory meatus, and against which lies the părotid gland.

(*b*) Sometimes a small foramen (**iter chordæ anterius**) close by the Glasserian fissure transmitting the *chorda tympani nerve.*

(*c*) The prominent free edge of the plate is double (**vaginal process**), and encloses

(*d*) The **styloid process,** a thin pointed process, sometimes articulated at its base and often broken in specimens, projecting downwards and forwards; it gives attachment to three muscles—*stylo-pharyngeus*, *stylo-hyoid*, *stylo-glossus*; and two ligaments—*stylo-hyoid* and *stylo-maxillary*.

(*e*) A foramen (**stylo-mastoid foramen**) is found in the depression between the styloid and mastoid processes and transmits the facial nerve and an artery.

(*f*) A rough surface for articulation with the jugular process of the occipital bone. Continuing inwards we find

(*g*) A smooth groove (**jugular fossa**) which helps to form the jugular foramen at the base of the skull and lodges the vein of that name.

(*h*) Sometimes a small foramen for Arnold's nerve (*auricular of pneumogastric*) in the jugular fossa.

(*i*) A large foramen (**carotid foramen**) anterior and internal to the jugular fossa, leading to a large canal in the bone and lodging the *carotid artery*.

(*k*) A small foramen in the plate between the jugular fossa and carotid foramen for Jacobson's nerve (*tympanic of glosso-pharyngeal*).

(*l*) A triangular depression leading to a foramen near the posterior border for a vein in the aqueductus cochleæ.

(*m*) A rough four-sided surface, forming the under part of the tip and giving attachment in front to two muscles—*tensor tympani* and *levator palati*.

(*n*) At the extreme tip the anterior opening of the carotid canal.

On the mastoid portion are seen—

(1) The auricular fissure.

(2) The tip of the mastoid process.

(3) A deep groove internal to the process and called the **digastric groove** for the *digastric M.*

(4) A narrow groove (**occipital groove**) internal to this for the *occipital artery.*

On the border extending from the tip of the petrous bone to the front of the squamous portion we notice—

(1) The anterior opening of the carotid canal.

(2) A large canal, the lower part of which is for the *Eustachian tube* to allow of air passing into the tympanum. Above this

(3) A smaller canal for a muscle (the *tensor tympani*) and

(4) A plate of bone between them called the **processus cochleariformis.**

The border now belongs to the squamous portion, and is at first rough for articulation with the sphenoid, then thin and bevelled on its inner surface to form the squamous suture. This is traceable backwards to the mastoid portion, where it again becomes rough and deeply indented, and sometimes presents the separate inter-sutural bones (wormian bones), seen more frequently in the occipito-parietal suture.

Articulations.—With 5 bones—malar, sphenoid, parietal, occipital, and lower jaw.

Development.—From 4 centres. Found in (*a*) squamous portion in the 7th or 8th week of fœtal life—this centre extends into the zygomatic process; (*b*) petro-mastoid in the fourth month, first seen over the cochlea in the front of the bone, with sometimes

separate nuclei for the semicircular canals; (c) tympanic ring in the 3rd month, extending afterwards to form the lower and front wall of the external auditory meatus; (d) styloid process in the 4th month. The different parts unite in the first year.

The ossicles are developed from separate centres in the 4th month.

Means of distinguishing right from left.—Hold as if in your own head, with the thin squamous edge upwards and the petrous portion directed forwards and inwards; the outer surface with the zygoma looks to the side to which the bone belongs.

Points of importance:—

1. Locked into the side of the skull, the petrous bone forming a specially strong buttress.
2. Containing the organ of hearing, and perforated by the carotid artery and facial nerve.
3. The petrous bone is generally broken through in fracture of the base of the skull, and consequently blood and cerebro-spinal fluid generally escape from the ear in such an accident.
4. Peculiar ring of the tympanic bone.

The interior of this bone will be examined separately, and the ossicles or small bones which lie in the tympanum considered at the same time.

ETHMOID.—Plate XVII.

Synonyms: *E.* Sieve bone, spongy bone. *G.* Das Siebbein. *F.* L'os ethmoïde. *L.* Os cribrum.

Situation.—The ethmoid occupies the cleft in the frontal bone between the two orbits, and forms the upper part of the nasal cavity.

Shape.—It is a cubical mass, very porous and honey-combed.

Parts.—It consists of a horizontal plate which occupies the base of the skull, a vertical plate which forms part of the septum of the nose, and two lateral masses of cells or cavities, suspended from a thin plate, which forms part of the inner wall of the orbit.

Taking the bone as a whole we find it resembles a cube in having six sides—upper, lower, two lateral, anterior and posterior.

Upper surface.—In the middle line is a projecting process (**crista galli**) continued backwards into a median ridge for the attachment of the *falx major*, and bounded in front by a foramen (**foramen cæcum**) for a vein. On either side is a groove (**olfactory groove**) perforated by numerous foramina for the olfactory nerves; the foramina are in three sets, the outer large for nerves going to the lateral masses, the inner also rather large for nerves going to the septum, the middle small for those going to the roof. By the side of the crista galli is a slit for the *nasal nerve.* Outside these foramina which occupy the horizontal plate are seen numerous large cavities, which are closed in by the frontal bone; these are some of the ethmoidal cells, and are filled with air.

Two channels are seen running obliquely across them, and are the **anterior** and **posterior ethmoidal canals,** the anterior being the larger and transmitting the nasal nerve.

Lower surface. In the middle is seen the vertical plate, on each side the lateral masses, the middle turbinated bones being prominent.

Lateral surfaces. Above is a smooth quadrilateral surface, the **os planum** or **orbital plate,** which forms the inner wall of the orbit, and presents two notches or foramina above (the **ethmoidal foramina**). Below, the middle turbinated is suspended, and a hooked process (**unciform process**) is curved outwards for articulation with the inferior turbinated bone.

Anterior surface. Above is the front of the crista galli, and running down from this the edge of the vertical plate for articulation with the nasal bones. The lateral masses are again seen on each side, very much hollowed out and open.

Posterior surface. In the middle is the thin edge of the vertical plate for articulation with the rostrum of the sphenoid. On either side the lateral masses are seen to be arranged in a double tier, a thin curved plate above (**superior turbinated bone**) overlying a space, the **superior meatus of the nose,** below which another curved plate, the **middle turbinated bone,** overlies a second space, the **middle meatus.**

If a section be made on one side of the vertical plate the arrangement of the cells or cavities is seen. (Compare Plate XXIII.) The superior turbinated bone is placed rather posteriorly, and the meatus receives the opening of the posterior ethmoidal cells; the middle meatus receives the opening of the an-

terior ethmoidal cells, together with a funnel-shaped canal, the **infundibulum**, from the frontal sinuses. Each of the turbinated bones is curved with the convexity inwards towards the septum.

Articulations.—With 15 bones, 3 being median—viz., frontal, sphenoid, and vomer, and 6 being on either side—viz., sphenoidal turbinated, nasal, superior maxillary, lachrymal, palate, and inferior turbinated.

Development.—From 3 centres, one for each lateral mass, commencing in the orbital plate in the 4th or 5th month, one for the vertical plate in the 1st year, spreading into the cribriform plate. The parts coalesce about the 5th or 6th year.

Points of importance:—

1. Its peculiar porous character.
2. The lateral masses suspended from the orbital plate appear in the nasal fossæ, and constitute together with the vertical plate of the bone the region in which the organ of smell is situated.
3. The cells arranged in two sets, the anterior opening with the infundibulum into the middle meatus, the posterior into the upper meatus of the nose.

FACIAL BONES.

SUPERIOR MAXILLA.—Plate XVIII.

Synonyms: *E.* Upper jawbone. *G.* Das Oberkieferbein. *Fr.* La mâchoire.

Situation.—It forms the greater part of the face between the orbit and the mouth.

Shape.—A hollow segment of a cylinder, with flattened and rough projections, the curved border of the cylinder bearing teeth.

Parts.—The hollow part is called the body, the border containing the sockets for the teeth the alveolar border, the horizontal plate running inwards to form the roof of the mouth the palatine process, that running upwards by the side of the nose the nasal process, the rough projection on the outer side the malar process.

Taking the bone as a whole it presents an outer and an inner surface. The outline has an anterior and a posterior border.

Outer surface limited below by the teeth, above by the inner edge of a nearly horizontal orbital plate. It presents three different surfaces, the facial, the orbital, and the zygomatic, owing to the projection of a rough process, the malar process. On the *facial portion* are seen as the bone is examined from above

(1) The triangular thin, but strong process (**nasal process**) projecting upwards for articulation with the frontal and nasal bones; this is marked by

(2) A ridge, which separates the facial from the orbital surfaces of the process and gives attachment to muscles.


LACRYMAL (RIGHT)
OUTER VIEW
w. Front.
Tensor tarsi
with Ethm.
w. Sup. Maxill.
w. Turb.
Lacrym. Tub.
Infra. orb. Gr.
Inner View
Malar Pr.
Post. Dent. C.
Buccinator
Tuberosity
SUPERIOR MAXILLA (RIGH
OUTER VIEW
Orbic palp
Nasal Pr.
Lev lab s et alæ nasi
Lacr. Gr.
Obliq. inf.
Orb. Pl.
Canine Foss.
Alveolar Pr
w. Sphen
with Ethmoi.
Shpen. Pal. for.
Obit. Pr.
OUTER VIEW
PALATE (RIGHT)
Eth. Sup. Max.
Tuberos.
Sphen. Surf.
Sphen. Pal. For.
Sphen Pr.
Orbital Pr.
Orbital Surf.
Tygom. Surf.
R. for mid. Turb.
P. Pal. Can.
R. for inf. Turb.
R. for inf. Turb.
Tuberos.y
med. Crest
Tens pal
Horiz. Pr.
Pteryg Foss.
Int. Pteryg
w. Ethmoid
w. Sphen.
with Sup. Max.
w. opp. Pal.
INNER


NASAL (RIGHT)
SUPERIOR MAXILLA (RIGHT)
INNER VIEW
PLATE XV
Front
w. Frontal
Upp. meat.
R. for Mid. Turb.
mid. meat.
R. for Inf. Turb.
Inf. meat.
Ant. Pal. Can.
Ant. Nas. Sp.
w. Vomer
Lacrym. Gr. Air Cells
with Ethmoid
Antrum
with Palate
Back
with Frontal
with opp. Nasal
with Sup. Max.
Gr. for Nas. N.
Pal. Pr. artic. w. opp. Sup. max.
MALAR (RIGHT)
w. Front.
Frontal Pr.
Zygom. Pr.
Malar F.
Orbital Pr.
with Spenoid
Temporalis
with Zygom.
Lev. lab. sup.
Maxill. Pr.
with Sup. Max.
Masseter
Zygomat. mi.
OUTER VIEW
INNER VIEW

(3) Below the inner extremity of the rough articular surface for the malar bone is the **infra-orbital foramen,** a large opening for the nerve and artery of the same name, and occupying the upper limit of a depression in the surface called

(4) The **canine fossa,** which lies above the bicuspids rather than the canine tooth.

(5) A shallow depression, **myrtiform** or **incisor fossa,**·above the incisor teeth, giving attachment to a muscle, the *levator anguli oris.*

(6) The **alveolar border,** occupied by the alveoli for the teeth.

On the *zygomatic portion* the surface is convex, and there are seen

(7) Several canals (**posterior dental canals**), and

(8) The rounded posterior edge (**tuberosity**), in which the last or wisdom tooth lies.

The *orbital surface* is smooth and horizontal, and shows

(9) A groove (**infra-orbital groove**) for the vessels and nerves of that name, and

(10) A deficiency behind the nasal process, which is the upper opening of the **lachrymal groove,** in which the lachrymal sac lies.

(11) The **malar process** which separates the three surfaces is prominent and rough for articulation with the malar bone.

Inner surface. Is divided into an upper and a lower part by the horizontal palatine process which projects inwards. Traced from above downwards we notice

(1) The inner surface of the nasal process, marked by

(2) A transverse ridge near the top for the middle

turbinated bone, below which the surface is conca
forming part of the middle meatus. Below this is

(3) Another ridge for the inferior turbinated bo and another concave surface below forming the inferi meatus of the nose, which extends on to the palati process.

(4) The body is hollowed out by the **maxilla sinus, or antrum of Highmore,** which is complet and closed in by the palate, ethmoid, lachrymal a inferior turbinated bones, but it communicates wi the nasal cavity in the middle meatus.

Not infrequently the fangs of the teeth proje into the antrum, generally the 1st bicuspid, but t cavity is easily opened by puncturing through t incisor fossa.

(5) The **palatine process** runs directly inwards a horizontal plate, smooth above, uneven below, a grooved towards the alveolar border for the *posteri palatine nerve,* articulating with the palate bo along its posterior edge and with the opposite maxi lary bone by

(6) A raised rough edge (the **crest**) which pointed in front, and forms

(7) The **anterior nasal spine,** and gives attach ment along its whole length to the septum of the nos

(8) On putting the bones of opposite sides togeth a foramen is left behind the incisor teeth, called th **anterior palatine foramen,** which transmits vessel and nerves of that name, and is curiously constructe the foramen being really compounded of four canals– the two side ones for the vessels, the front one fo the left nerve, the back one for the right nerve.

(9) Below the palatine process is seen the alveola border.

Anterior border. A large notch forms the outer limit of the anterior nares, or bony opening of the nasal cavity, and the anterior nasal spine projects forwards from the union of the two bones of opposite sides.

Posterior Border. Commencing behind the nasal process we find the lachrymal groove, then the margin of the orbital plate, then a rough edge behind the body for the palate bone, a prominent tuberosity, and a sharp edge behind the palatine process.

Articulations.—With 9 bones—frontal, ethmoid, vomer, two nasal, two malar, two lachrymal, and two inferior turbinated.

Development.—Probably from four centres, about the 6th or 7th week, one for the nasal process and facial portion, one for the orbital and malar part, one for the palatine process, and one for the incisor portion. The latter forms in all mammals except man a separate bone (the inter- or præ-maxillary bone) and forms in many cases of hare-lip or congenital fissure a projecting snout suspended from the vomer, producing great deformity.

Means of distinguishing right from left.—Hold as if in your own face, with the pointed nasal process upwards, the alveolar edge downwards, and the nasal notch and incisor teeth forwards; the convex surface with its projecting malar process look outwards—*i.e.*, point to the side to which the bone belongs.

Points of importance :—

1. The body is hollowed out by the antrum which opens into the middle meatus, but the orifice may be closed, and then fluid collects in and distends the antrum, and must be let out. This may be done by

removing a tooth—generally the first bicuspid—by puncturing through the canine fossa.

2. This bone is very liable to disease, both by e: tension from diseased teeth and by new growth Tumours sometimes fill and distend the antrum, aı not infrequently grow from the periosteum of tl alveolar border.

PALATE.—Plate XVIII.

Synonyms: G. Das Gaumenbein. *Fr.* L'os palatin. *L.* Os palatinum.

Situation.—At the back of the nasal fossæ, between the superior maxilla and the pterygoid processes.

Shape.—Like the letter L.

Parts.—It consists of a vertical plate surmounted by two processes, and an intervening notch. A horizontal plate forms the back of the hard palate.

Examining the bone as a whole, it is to be looked at in the following aspects: outer, inner, under, anterior, and posterior.

Outer aspect. Commencing above we notice two thin angular processes separated by a notch or foramen.

(1) The larger or **orbital process** is anterior, is four-sided, and marked off into three surfaces on this aspect—*anterior* or *orbital*, small, triangular; *posterior* or *zygomatic* larger, four-sided, seen in the zygomatic fossa; *inferior* or *maxillary*, small, continuous with the outer surface of rest of plate, and articulating with the superior maxillary bone.

(2) The smaller or **sphenoidal process** is posterior and internal, triangular, marked by a vertical ridge so as to leave a small grooved surface (*zygomatic*) in front, which appears in the zygomatic fossa, and a larger rough surface (*pterygoid*) behind for articulation with those processes, and lastly, a small, nearly horizontal surface above, the *sphenoid*, for articulation with the sphenoid bone.

(3) The **spheno-palatine notch** or foramen
tween these two processes, transmitting the n
and vessels of the same name.

(4) The **tuberosity** projects backwards at
lower angle of this surface, and fits between
tuberosity of the superior maxilla and the exte
pterygoid plate, a small grooved surface being in
zygomatic fossa, and giving attachment to the *int*
pterygoid M.

Inner aspect. This shows both the horizontal
vertical plates. Tracing from above downwards
notice on

(1) The **orbital process,** a large hollow four-s
surface, the *sphenoidal,* for articulation with the b
of the sphenoid, limited below by

(2) A rough crest (**middle turbinated crest**
the middle turbinated bone. A continuation of
ridge also limits the lower edge of

(3) The **sphenoidal process,** on which i
grooved surface, the *nasal,* for the upper meatu
the nose.

(4) Below the middle turbinated crest the su
is grooved for the middle meatus, and lower dov
marked by a second ridge, the **inferior turbin**
crest, for the inferior turbinated bone, and below
is another grooved surface for the inferior me
continuous with the upper surface of

(5) The **horizontal plate,** which articulates
its fellow of the opposite side by means
prominent

(6) **Crest,** which terminates behind in

(7) The **posterior nasal spine.**

(8) The inner side of the **tuberosity** is also
but is not prominent in this direction.

Under aspect includes (1) **horizontal plate**, and (2) **tuberosity**, and between them (3) a deep groove (**posterior palatine groove**), which is converted into a canal by articulation with the superior maxilla, and transmits vessels and nerve of the same name. On examining the outline of the tuberosity we see (*a*) a rough surface for the superior maxilla, immediately in front of the posterior palatine groove, then (*b*) a smooth surface, which presents itself in the zygomatic fossa, and gives attachment to the *internal pterygoid M.*; (*c*) a rough depression for the external pterygoid plate; (*d*) a smooth groove, forming the bottom of the pterygoid fossa, and (*e*) a rough depression for the internal pterygoid plate.

Anterior aspect. Shows the *sphenoidal*, *orbital*, and *maxillary* surfaces of the **orbital process**, which does not quite hide the **sphenoidal process** behind. The horizontal plate is seen leaving the vertical at right angles, and the tuberosity is seen in the distance.

Posterior aspect. On (1) the **sphenoidal process**, which is the nearer of the two processes, we see the sphenoidal and pterygoid surfaces.

On (2) the distant **orbital process** are seen the sphenoidal, orbital, and zygomatic surfaces.

(3) On the posterior edge of the **vertical plate** may usually be seen the groove or canal for the posterior palatine nerve, and the middle and inferior turbinated crests project on the inner side.

(4) On the **tuberosity** are seen three vertical grooves on this aspect, the two outer being articular for the two pterygoid plates, the middle forming the bottom of the pterygoid fossa.

(5) The posterior margin of the **horizontal plate** is smooth, and gives attachment to the soft palate, and

the inner end projects upwards, as the posterior na
spine.

Articulations.—With 7 bones—sphenoid, ethmo
superior maxilla, inferior turbinated, vomer, sphenoic
turbinated and opposite palate bones.

Development.—From a single centre, appearing in t
7th or 8th week at the angle between its ascendi
and horizontal parts. In the fœtus the horizon
part is much the larger.

Means of distinguishing right from left.—Hold as if
your own skull, with the palatine plate direct
towards the middle line below, the tuberosity pr
jecting backwards, and the curious double proce
looking upwards; the posterior margin of the palati
process will be non-articular; the side of the bo
from which the ascending process springs will be t
outer—*i.e.*, looks to the side to which the bone b
longs.

Points of importance:—

1. Its shape like the letter L, its numerous co
plicated processes, the ascending being divided by
notch.

2. A small portion appears in the orbit. The bo
is generally broken when disarticulated, and is ther
fore difficult to be learned.

MALAR.—Plate XVIII.

Synonyms: *G.* Das Iochbein, Wangenbein. *Fr.* Os de la pomette. *L.* Os malæ, malare, zygomaticum.

Situation.—It forms the prominence of the cheek, and enters into the orbit and temporal and zygomatic fossæ.

Shape.—Four-sided, with one side concave, and a flange thrown off from it inwards.

Parts.—Two surfaces, four borders, and four processes.

Surfaces. Outer or *facial* smooth, convex, perforated by one or more **malar foramina.** *Inner* or *zygomatic* rough in its anterior third for articulation with the superior maxillary, smooth behind for the temporal and zygomatic fossæ.

Borders. Upper or *orbital* is concave, smooth, and forms about one third of the circumference of the orbit on the outer and lower side; it has projecting from it inwards the **orbital process** or curved ledge, which contributes to the formation of the orbit and of the temporal fossa. *Lower* thick, free, continuous with that of zygoma, and giving attachment to the *masseter M. Anterior* rough, articular for the malar tuberosity of the superior maxilla. *Posterior* only non-articular in the middle third, where it forms a smooth notch, and gives attachment to the temporal fascia.

Processes. **Orbital** described above. **Frontal** is the angle of junction of the upper and posterior borders, and articulates with the external angular process of the frontal bone. **Zygomatic** is the angle

of junction of the posterior and lower border, projects most below and supports the zygomatic process of the temporal bone.

Maxillary is the rough triangular surface at the junction of the anterior and lower borders.

Articulations.—With four bones—frontal, sphenoid, temporal, and superior maxillary.

Development.—From a single centre in the 7th or 8th week.

Means of distinguishing right from left.—Hold as if in your own skull, with the concave orbital edge forwards, and from this edge the orbital surface running inwards; the posterior or zygomatic edge is more sinuous than the anterior, and the rough malar process is directed downwards; the smooth facial surface with its malar foramina is on the outer side—*i.e.*, looks to the side to which the bone belongs.

Points of importance:—

1. It forms part of the zygoma, which being arched over the temporal fossa is rarely broken, though exposed to frequent violence.

2. It gives the appearance called "high cheek bone" when large.

NASAL.—Plate XVIII.

Synonyms: *G.* Das Nasenbein. *L.* Os nasi.

Situation.—The two nasal bones form the bridge of the nose.

Shape.—Oblong, with the outer edge long and thin and the lower edge notched.

Parts.—*Outer surface* convex. *Inner surface* concave from side to side, grooved by the nasal nerve. *Upper border* narrow, thick, articulates with the nasal notch of the frontal bone. *Lower* thin, notched, but the nasal nerve frequently does not pass through the notch; this border is oblique and gives attachment to the lateral cartilage of the nose. *Inner* thick, straight, bevelled on its inner side so that the two nasal bones when articulated shall form an arch; it articulates with the nasal spine of the frontal and with the vertical plate of the ethmoid. *Outer* thin, much longer usually than the inner, articulates with the nasal process of the superior maxillary bone.

Articulations.—With four bones—frontal, ethmoid, superior maxilla, and opposite nasal.

Development.—From a single centre about the 7th or 8th week.

Means of determining right from left.—Hold with the notched, thin, oblique edge downwards, and the concave surface backwards; the longer of the two lateral borders is the outer—*i.e.*, looks to the side to which the bone belongs.

Points of importance:—

1. It forms the bridge of the nose, and though comparatively thin, is capable of resisting much violence without being broken, owing to its arched construction.

2. Peculiar notch on the lower edge.

LACHRYMAL.—Plate XVIII.

Synonyms: *G.* Das Thränenbein. *Fr.* Lacrymal.
L. Os lacrymale, unguis.

Situation.—Behind the inner angle of the orbit.

Shape.—It is an extremely thin, four-sided scale of bone, resembling a finger-nail, and hence sometimes called ungual bone, it is the thinnest and smallest bone of the face, and is often destroyed in the articulated skull.

Parts. The *outer surface* is often marked by a vertical ridge, in front of which the bone is grooved to form part of the lachrymal groove, behind which it is flat and forms part of the inner wall of the orbit. If the ridge be traced downwards it is seen to end in a small tubercle (the **lachrymal tubercle**) which articulates with a process on the orbital plate of the superior maxilla: it is, however, sometimes a separate bone and is called then the **lesser lachrymal bone.** *Inner* or *nasal surface* presents a vertical groove instead of the ridge, dividing the nasal from the orbital portion: the lowest edge, which is towards the front of the bone, articulates with the inferior turbinated bone.

Articulations.—With four bones—frontal, ethmoid, superior maxilla, and inferior turbinated.

Development.—From a single centre about the 7th or 8th week.

Means of determining right from left.—Hold with the small tongue-like process projecting downwards and the vertical groove which ends in this process

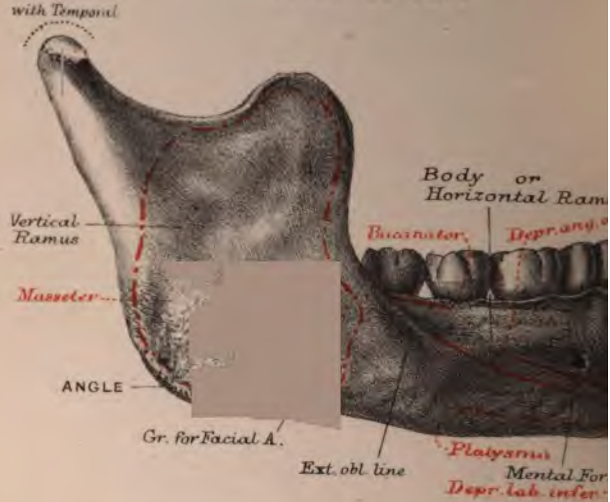
forwards, the surface upon which the vertical ridge is found is the outer—*i.e.*, points to the side to which the bone belongs.

Points of importance :—

1. Extremely thin and like a finger-nail—it is generally destroyed in an old skull.
2. It is grooved for the lachrymal duct.

LO

OUTER SURFACE

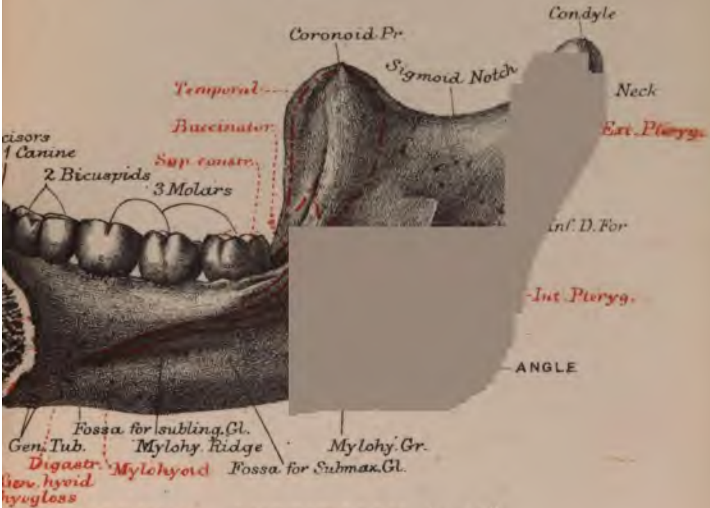


VOMER (seen from right side)

PLATE XIX.

N (*right*)

INNER SURFACE



INFERIOR TURBINATED (*right*)

OUTER SURFACE

INNER SURFACE

h.

INFERIOR MAXILLA.—PLATE XIX.

Synonyms: *E.* Lower jawbone. *G.* Der Unterkiefer. *Fr.* La mandibule. *L.* Os maxillare inferius, mandibula.

Situation.—This bone constitutes the lower jaw and articulates with the temporal bone on each side.

Shape.—It consists of two halves, uniting in the middle line at the symphysis; it forms a horseshoe with two perpendicular rami at the ends of the horseshoe, the upper edge of the horseshoe bearing the teeth.

Parts.—The horseshoe portion is called the **body**; the ascending portions the **rami**. The border bearing the teeth is called alveolar, and the rami are surmounted by two processes, the posterior of which is the articular condyle, the anterior the coronoid process.

Examining the bone as a whole we find the two halves alike, and each half has an outer and an inner surface, an upper and lower border.

Outer surface. On the ascending portion or ramus we notice—

(1) A four-sided moderately smooth surface, which gives attachment to the *masseter M.*

(2) A prominent angle belonging rather to the border, and situated at the junction of the ramus with the body. On the body is seen

(3) A line continued from the anterior border of the ramus (**exterior oblique line**) running obliquely across the body and ending below a foramen called

(4) **The mental foramen**, which transmits the termination of the *inferior dental nerve* and artery,

and gives attachment to muscles, *depressor anguli oris* and *depressor labii inferioris Ms.*

(5) The upper part of the body contains the sockets for the teeth, and is called the **alveolar border.**

(6) The **symphysis menti,** or line of union between the two halves of the bone.

(7) A depression below the incisor teeth, to which is attached the *orbicularis oris M.*

(8) Another depression below this for the *levator menti M.*

The *inner surface* presents on the ascending ramus

(1) A foramen (**inferior dental foramen**) for the *inferior dental vessels* and *nerve*, and for a long *Meckel's cartilage* in the fœtus, continuous with the processus gracilis of the malleus; projecting upwards from the inner edge of this foramen is

(2) A spinous plate of bone for the *internal lateral ligament* of the lower jaw.

(3) A groove running obliquely from the foramen (**mylo-hyoid groove**) for the *mylo-hyoid nerve* and *vessels.*

(4) A rough surface between this and the angle for the insertion of the *internal pterygoid M.*

On the body are seen

(5) A ridge (**mylo-hyoid ridge**) continuous with the anterior border of the ramus and running obliquely across the body, giving attachment to the *mylo-hyoid M.*, leaving a fossa below

(6) The **submaxillary fossa** for the submaxillary gland, and above and in front is seen

(7) A fossa (**sublingual fossa**) for the sublingual gland.

(8) Two tubercles on either side behind the symphysis (**genial tubercles**); the upper for the *genio-hyoglossus*, the lower for the *genio-hyoid M.*

Borders. Commencing at the posterior process at the upper limit of the ramus we notice—

(1) The posterior process or **condyle,** an articular process, the long axis of which is nearly transverse, with a slight inclination backwards as well as inwards, rounded from before backwards, and slightly so from side to side, for articulation with the glenoid cavity of the temporal bone.

(2) A constricted portion below the condyle forming the **neck,** having a rather flat hollow surface in front for the insertion of the *external pterygoid M.*

(3) A notch in front of the condyle (**sigmoid notch**).

(4) An anterior thin angular process (the **coronoid process**) for the insertion of the *temporal M.*

(5) The anterior edge of this process is grooved.

(6) On the body the border is called **alveolar,** and contains the sockets for the teeth, which are eight in number on each side in the adult (3 molars, 2 bicuspids, 1 canine, and 2 incisors), and in the young bone only five (2 molars, 1 canine, and 2 incisors). In the adult the sockets for the molars are usually double for the two fangs, whereas in the upper jaw each molar tooth has usually three fangs; the wisdom tooth, however, has generally only one or two fangs.

Outside the molar teeth the *buccinator M.* is attached, and the *superior constrictor* of the pharynx, the two muscles being separated by the *pterygo-maxillary ligament.*

Tracing the lower border from the condyle we notice—

(1) The back of the neck of the condyle.

(2) The thick posterior margin of the ramus, t nating in

(3) The **angle.**

(4) Continuing along the under edge of the we notice a groove in front of the insertion c masseter for the *facial artery*, in which position p tion is easily felt in man and in the horse, dog other animals.

(5) A depression on each side of the symp for the anterior belly of the *digastricus M.*, above this edge of the body the *platysma M.* tached.

Articulations.—With the two temporal bone the glenoid fossæ.

Development.—From two centres—one for each but occasionally others for the coronoid proce condyles, angles, and the inner side of the alve This bone begins to ossify before any bone, ex the clavicle, about the 6th week of fœtal life, the two halves unite in the first year: the d canal is at first an open groove. *At birth* the alve border is small; the mental foramen therefore h and the angle obtuse. After birth the sockets the milk or first set of teeth become more pronoun In *adult life* the alveolar and basilar portions are ne equal; the mental foramen, therefore, midway, ramus vertical, and the sockets for the perma teeth evident. In *old age* the alveolar border beco absorbed, owing to the loss of the teeth, the me foramen therefore near the upper border, the ra oblique, and the angle obtuse.

Points of importance:—

1. Its alveolar border with the sockets for

teeth, which differ in number in the first and second or permanent set. The sockets also for the molars differ from those for the upper molars.

2. The two large processes, coronoid and condyle, and the intervening sigmoid notch.

3. The peculiar grinding motion allowed of at the temporo-maxillary joint, and the immense strength obtained by the horseshoe shaped body.

4. The difference between the bones of the child, adult, and aged person.

This bone is often broken by direct violence, and the fracture generally occurs about an inch from the symphysis. When broken it is often difficult to retain the fragments in position, and recourse is had to various means for effecting this purpose. The teeth may be tied together, or a mould fixed over them, or the portions of jaw may be fastened together by wire, but usually the best method is to close the mouth and fix it in that position by a split bandage. The lower jaw is often dislocated, and the condyle then slips forwards on to the eminentia articularis. The mouth is then wide open, and there is often much difficulty in reducing it. Gaping or laughing is the common cause of the dislocation.

VOMER.—Plate XIX.

Synonym : *G.* Das Pflugscharbein.

Situation.—It is placed as a single bone in th median line below the body of the sphenoid, an forms the back part of the septum of the nose.

Shape.—Obliquely four-sided, thin, with a prc jecting ala on each side of the base.

Parts.—It has two lateral surfaces and four border

Lateral surface smooth, furrowed, marked by on special groove or canal for the *naso-platine nerv* running downwards and forwards.

Borders.—*Upper* thickest, with a deep groove fc the rostrum of the sphenoid, and two alæ (**vagina processes**) which fit into grooves at the root of th internal pterygoid plates. *Lower* articular, thi behind for the interpalatine suture, thicker in fron for the intermaxillary suture. *Anterior* thin or doubl above, and rather horizontal for articulation with th ethmoid; broader, perpendicular, and irregular belo for the median triangular nasal cartilage. *Posteric* smooth, non-articular, forms the posterior border the septum in the posterior nares.

Articulations.—With six bones—two median an belonging to the cranium, sphenoid and ethmoid two in pairs and belonging to the face, superic maxilla and palate.

Development.—From two centres — one for eac lateral half, appearing in the 7th or 8th week an uniting shortly after birth.

Points of importance :—

1. It forms the septum of the nose, and frequently more on one side than the other.

2. It is grooved for the naso-palatine nerve.

INFERIOR TURBINATED.—Plate XIX.

Synonyms: *E.* Lower spongy bone. *G.* Das Muschelbein. *Fr.* Le cornet, la coquille inférieure. *L.* Concha inferior, os turbinatum, spongiosum.

Situation.—On the lower part of the outer wall of the nasal fossa.

Shape.—Curved, scroll-like, thin, with a dependent process on the outer side.

Parts.—Two surfaces, two borders, and two ends.

Surfaces. *Inner* convex, rather uneven, marked by vertical grooves for branches of the fifth nerve and for vessels. *Outer* concave, overlying the inferior meatus of the nose, presenting a triangular dependent process (**maxillary process**) towards its posterior end, which articulates with the maxillary bone just below the orifice of the antrum.

Margins. *Upper* convex, thin, irregular, marked by two small projections which divide it into thirds; the anterior process is the **lachrymal process,** the posterior the **ethmoidal process** for articulation with the bones of those names. In front of the lachrymal process the bone articulates with the nasal process of the superior maxillary, behind the ethmoidal process with the ridge on the ascending plate of the palate bone. *Lower* convex, thin, free.

Ends. *Anterior* slightly more pointed than the *posterior.*

Articulations.—With four bones—ethmoid, superior maxilla, lachrymal, and palate.

Development.—From a single centre about the 5th month.

Means of distinguishing right from left.—Hold with the pointed longer end forwards, and the pendent maxillary process downwards; the maxillary process will be on the outer side—*i.e.*, will point to the side to which the bone belongs.

Points of importance :—

1. It is the only one of the three turbinated bones which is a separate bone, but sometimes it is united to the inferior maxillary.

2. It is covered by nasal but not olfactory mucous membrane, and is not infrequently the seat of polypi, or soft tumours. In removing these care should be taken not to pull away the bone.

THE SKULL AS A WHOLE.

If we look at the bones of the skull when articulated together, we shall see the relation of the various prominences and foramina to one another, whereas hitherto we have only seen their relationship when they happen to be in the same bones. The bones of the skull and face form an oval box, the upper and back part of which contains the brain, and constitutes the cranium proper, while the anterior and lower part constitutes the face, and contains the organs of taste, and sight, and smell. We must bear in mind the relative importance of the contents of the cranial and facial regions while we examine the skull as a whole, as it will tend to explain the difference in uniformity and structure.

Anatomically we may notice the skull in certain aspects, and in each we shall see numerous points already described, besides others which are of interest in relation to the external configuration of the head

and face, or which indicate special developments of the brain, and bear upon phrenology.

Front View (Plate XXI).—In examining the front of the skull we see the general outline is oval, with the broader part above. The greater breadth and height of the cranial portion corresponds with the development of the brain, while the lower part of the face is larger in animals, and even in man indicates, when excessively developed, a predominance of the animal character. Breadth in the frontal region is generally associated with what we may roughly call breadth of intellectual faculties, in contradistinction to the depth or intensity of intellectual as well as moral faculties usually indicated by the height of this region. Breadth again is said by phrenologists, and with some reason, to indicate intellectual, while height indicates moral tendencies of the mind.

In looking at this front view of the skull it must be remembered that the hair of the scalp covers the upper part of the frontal bone—about the upper half in a normal face. Various measurements may be taken for the relation of parts in a typical face, but one of the simplest is that of dividing the front view of the head into four zones, marked by three horizontal lines. Through (1) the root of the hair on the forehead, (2) the root of the nose and middle of each eye, (3) the lower limit of the nose. In the skin-covered face the lowest zone is subdivided into three equal parts by the line of the mouth, and by that of the crease above the chin. The orbits are large compared with the anterior nares, but in the natural face the opening of the eyelids is only equal to the width of the nose, and the whole width of the face is usually equivalent to that of five eyes.

How much of the character of a face depends u these proportions! Little though we think of tl yet they are accepted intuitively, and any ext divergence from them strikes the observer pleasantly. It is when the rule is broken tha notice how a deviation from it strikes unpleas upon our sight. When the eyes are small or cl set, when the forehead is low and narrow, the instinctively repels, unless redeemed by some sp expression. Eyes that are large and widely sepa give to the face a repose which is perhaps bro to an unfathomable extreme in the sphinx's h where we must remember the type of beauty is Caucasian but Egyptian.

Tracing from above downwards we notice was seen on the front of the frontal bone, prominent edge of the *temporal fossa*, formed on aspect by parietal, frontal, and malar bones; the l *orbital fossæ*, or orbits, with the *supra-orbital f men* above, and *infra-orbital foramen* below; and serve that the malar bone forms rather more half the lower edge of the orbit. Going to the mi line we see the depression at the junction of fro and nasal bones which forms the depression at root of the nose. Below the nasal bones, the p shaped *anterior nares* with the *anterior nasal s* below, and leading into the *nasal fossæ* which separated deeply by the vomer and vertical plat the ethmoid: in the natural state the septum is c tinued forwards by the cartilage of the sept Below again is the *alveolar border* with the teeth, the front surface of the lower jaw. Tracing wards from the anterior nares, we pass over *canine fossa* and reach the *malar tuberosity*, which w

the superposed malar bone forms the prominence of high cheek-bones seen in the negro skull and in other races. Immediately below this is a hollow naturally filled by fat, but when deprived of this, as after wasting diseases and famine, the depression caused gives rise to the appearance called hollow cheeks.

Side view (Plates XXI. XXII).—In this view we notice again the difference between facial and cranial portions, and that the cranial portion is considerably larger than the facial. Comparing the skull with the skin-covered head (by means of a looking-glass if no other means be possible), it will be noticed that in the face the *temporal fossa* contains part of the frontal sphenoid and temporal bones covered by tissue; that part of the cranium proper is not covered by hairy scalp. Moreover it may be noticed that the ear occupies a space equivalent to that between the eyebrow and the lowest point of the nose; and that the *external auditory meatus* is situated nearly at an equal distance from (1) the root of the nose, (2) the vertex of the skull, and (3) the occipital protuberance. This point is taken advantage of by phrenologists, and it may be said that the greater distance between the orifice of the ear and the front of the cranium, corresponds with greater development of intellectual faculties, to the vertex with moral, and to the occiput with animal powers. In an individual the relation between these faculties may usually be roughly estimated by such means, but it must always be borne in mind that such observations are liable to error from various sources, as for instance thickness of skull, and that in comparing the measurements in different individuals very little reliance can be

placed on such rough methods, for it is impossible to estimate the depth of the convolutions, a point of apparently great importance in estimating the activity of the brain.

It may next be noticed that in an ordinary European (Caucasian) skull, the horizontal line of the base of the skull passes through the lower limit of the anterior nares, or in other words through the junction of the nose and upper lip, and that, considering the articulation with the spine is in a line between the front of the two mastoid processes, the greater size and weight of skull will be in front of the fulcrum, or part at which the head is in contact with the atlas. The stronger muscles are therefore placed at the back of the neck, together with a strong fibrous ligament, the ligamentum nuchæ. A person sitting upright nods his head forward when falling asleep, owing to the greater weight being in front of the fulcrum.

Next look at the general outline, and notice what is termed the facial angle as indicating development of intellectual powers in the human race. To form this angle, a facial line is drawn from the most prominent point of the forehead to the most prominent point of the upper jaw. Intersect this by a basal line drawn through the external auditory meatus to the base of the anterior opening of the nose. The angle formed at the point of meeting of these two lines (Camper's facial angle), differs much in different races; in the Caucasian or Indo-European skull it is 80° to 85°; in the Mongolian or Chinese about 75°; in the Ethiopian or Negro about 70°; in the gorilla about 38°; in the orang-otang (Owen) 30°; in the mastiff 41°; in the horse 23°. Greek sculptors increased it to 90° in representing sages and

heroes; and when they wished to convey an idea of superhuman intellect, they extended it to 100°, as in the Apollo and Medusa.

It is usual to distinguish certain varieties of human skulls, and we may here refer to the simplest of these, and mention the special characters by which they are marked. Examination of a large number of skulls has enabled authors to select at least three typical forms.

(1) The oval or elliptical or Caucasian.

(2) The pyramidal or Mongolian, and

(3) The prognathous or Ethiopian.

The *Caucasian* is the most perfect, is rounded and symmetrical; when seen from above, its posterior extremity bears to the anterior the proportion of about 3 to 2; face oval, its area in section being about 1 to cranium 4.

Mongolian appears broader but much shorter from before backwards; face square and flat; cheek-bones and zygomatic arch projecting laterally; nasal bones short, small; space between the eyebrows (glabella) flat and broad; jaws wide; dental arches flattened in front. This form is exemplified in Tartars and in some of the native tribes of America.

Ethiopian conveys the idea of lateral compression; the narrowness of the temples allows the zygomatic processes to come in view, the cheek-bones, jaws, and incisor teeth project considerably forwards, hence called by Dr. Pritchard *prognathous;* the nose flat, the face narrow, its area in section being one-fifth larger proportionably than in the Caucasian; jaw large and strong, teeth perfect and durable.

Taking the capacity of the cranium to be represented by figures it would be proportionally in the Caucasian 40, Mongolian 39, Ethiopian 37.

Such skulls as are broad in comparison with their length are termed Brachycephalic, and those which are comparatively long Dolichocephalic. Upon this latter basis Retzius's table is drawn up. His subdivisions are dependent upon the facial angle, the orthognathous having a vertical outline of the face or a large facial angle, while the prognathous have prominent teeth, and a receding forehead or a small facial angle.

CLASS I.—DOLICHOCEPHALIC, OR LONG HEADS.

Order 1. *Orthognathæ.* — Gauls, Kelts, Britons, Scots, Germans, Scandinavians.

„ 2. *Prognathæ.* — Greenlanders, various North and South American Indians, such as Caribs, &c., Negroes, New Hollanders.

CLASS II.—BRACHYCEPHALIC, OR BROAD HEADS.

Order 1. *Orthognathæ.*—Sclavonians, Finns, Affghans, Persians, Turks, Lapps.

„ 2. *Prognathæ.* — Tartars, Kalmuks, Mongols, some North and South American races, such as Incas, Caruas, &c., Papoes.

Mr. Ward has made some interesting experiments on the relative capacity of the anterior and posterior portions of the cranium; taking the anterior boundary of the foramen magnum as the line of division (and it may be noticed that this corresponds very closely to the line of the external auditory meatus), he infers from these observations that in the flat-headed Indian, Chinese, Esquimaux, and African, the posterior segment is the larger; while in the German, Greek, and Hindoo the anterior is the larger; and

further that even where the greater capacity of the entire cranium seems at first sight to place the African, &c., above the Caucasian skull, still a comparison of the anterior segments shows the superiority of the latter.

The following table, taken from that of Dr. Morton's in the "Transactions of the American Medical Associations," will be of interest as showing the relative capacities of the crania of different races of mankind. It must, however, be borne in mind that the classification is not free from objection.* The figures indicate the number of cubic inches of measurement.

Races and Families.	Mean capacity of the skull in cubic inches.
MODERN CAUCASIAN GROUP.	
Teutonic Family.	
Germans	90
English	96
Anglo-Americans	90
Pelasgic Family.	
Persians, Armenians, Circassians	84
Celtic Family.	
Native Irish	87
Indostanic Family.	
Bengalees, &c.	80
Semitic Family.	
Arabs	89
Nilotic Family.	
Fellahs	80

* Upon the character of the skulls of the American and Malay Groups I have added some remarks in the commencement of the book, immediately following the preface.

Races and Families.	Mean capacity of the skull in cubic inches.
ANCIENT CAUCASIAN GROUP.	
Pelasgic family.	
Græco-Egyptians	88
Nilotic Family.	
Egyptians	80
MONGOLIAN GROUP.	
Chinese Family	82
MALAY GROUP.	
Malayan Family	86
Polynesian Family	83
AMERICAN GROUP.	
Toltecan Family.	
Peruvians	75
Mexicans	79
Barbarous Tribes	84
(Iroquois, Cherokee, &c.)	
NEGRO GROUP.	
Native African Family	83
American-born Negroes	82
Hottentot Family	75
Alfornian Family.	
Australians	75

Having noticed the relation between the cranium and face in the side view, we next remark that the prominence over the frontal sinuses is much more marked in some skulls than in others; but this cannot be taken to indicate the special development of any faculties of the brain. Next the nasal bones project at an angle, and give rise to the appearance called the bridge of the nose, sometimes very marked indeed, and when lost by accident or disease great deformity is produced; it is, however, upon the

arrangement of skin and cartilage more than to the bone that we are dependent, for the comeliness of an organ whose beauty is not appreciated till it is injured or lost.

The prominence of the lower border of the lower jaw varies according to age as well as according to individual peculiarities; it is especially pronounced in the aged or toothless, and is increased by the falling in of the lips over the alveolar borders, owing to the absence of the teeth.

The angle of the jaw in like manner is modified by age, being obtuse in early life, rectangular in adult, and obtuse again in old age.

The outline of the vault forms an arch, seen in the side view as well as from the front, and is admirably adapted by its shape to protect the delicate brain within.

Tracing the surface downwards we notice the *parietal eminences*, at which points the skull is broadest, the *temporal ridge* and margin of the *temporal fossa* seen on the frontal, parietal, temporal and malar bones, the fossa including the sphenoid also. The size of this fossa depends upon the size of the temporal muscle, which is one of the most powerful muscles for closing the jaws. Hence it is greatest in the carnivora, where it occupies the whole side and upper part of the skull, and is increased in extent by strong bony ridges. In front of the malar bone is the *orbit*, and upon the bone the *malar foramina*, while below it projects as the *maxillary process*, overlying a space which is filled naturally by the masseter muscle and fat. Deeply placed under cover of the zygoma is the *zygomatic fossa*, with a still deeper hollow, the *spheno-maxillary fossa*, between the pterygoid processes and the

upper jaw. Behind the condyle of the lower jaw, seen now in its *glenoid cavity*, is the *external auditory meatus*, and behind this the *mastoid process*, lying over the articulating processes or condyles of the occipital bone. Extending from the mastoid backwards is the *superior curved line* which ends at the *exterior occipital protuberance*. Upon the several bones are seen the markings and foramina described on their outer surfaces, some of which have already been mentioned in speaking of the front view of the skull. Of the sutures it is especially necessary to notice the projection forwards of the anterior inferior angle of the parietal to meet the great wing of the sphenoid.

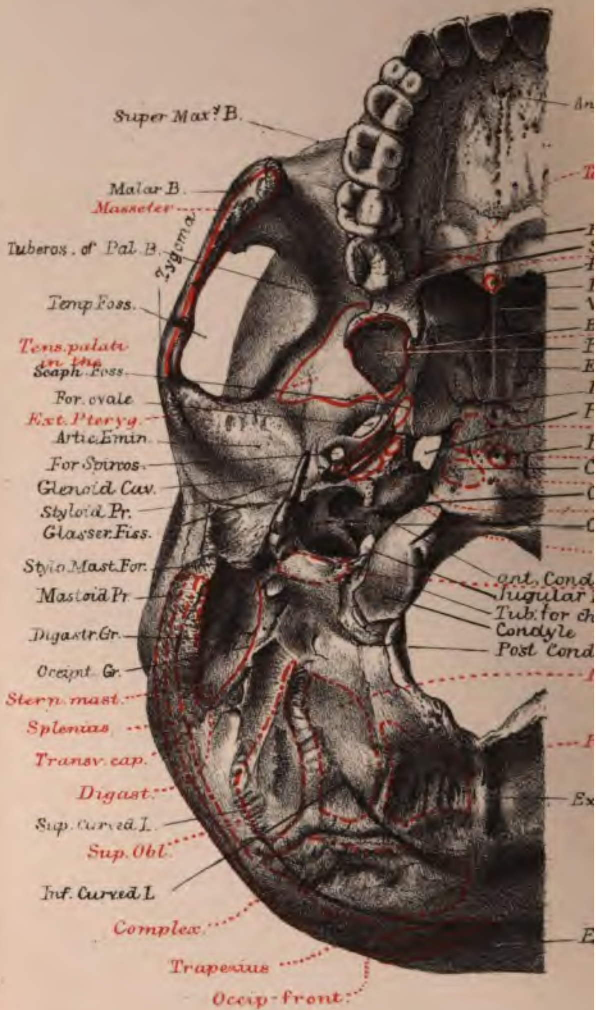
Top view. This view gives the outline of the skull cap, forming an oval with the broad transverse axis rather behind the middle, and at or about the parietal eminences, and the median line corresponds nearly with the interparietal or sagittal suture. But the outline is not always symmetrical, in fact it is rarely perfectly so, and it can sometimes be seen that one-half is greater than the other, the left being usually the larger. This is in accordance with a fact in cerebral physiology, that the left half of the brain is the storehouse of nerve force for the right half of the body, and inasmuch as the majority of individuals are right-handed, or use the right side more than the left, the left half of the brain is proportionally the larger.

In looking at the top of a skull of the Mongolian or Ethiopian form, the special peculiarities of these types may be seen, the Mongolian being broad and short, the Ethiopian comparatively long and narrow, the zygomatic arches much projecting.

The *parietal foramina* are seen on either side of the sagittal suture.

BASE OF

EXTERIOR



INTERIOR.


Gr. for ant. mening. A.
Frontal Crest
Gr. for Sup. L. Sinus
For. Caecum
For. for Nasal N.
Crista Galli
Anterior Fossa
Mid. Foss.
Basilar Pr.
Gr. for 6th N.
Inf. Petr. Sin.
Ant. Cond. For.
Post. Cond. For.
Gr. for Lat. Sin.
Mastoid For.
Postern Fossa
Torcular Herophi.
Int. occip. crest

FACE (right half).
FRONT VIEW.

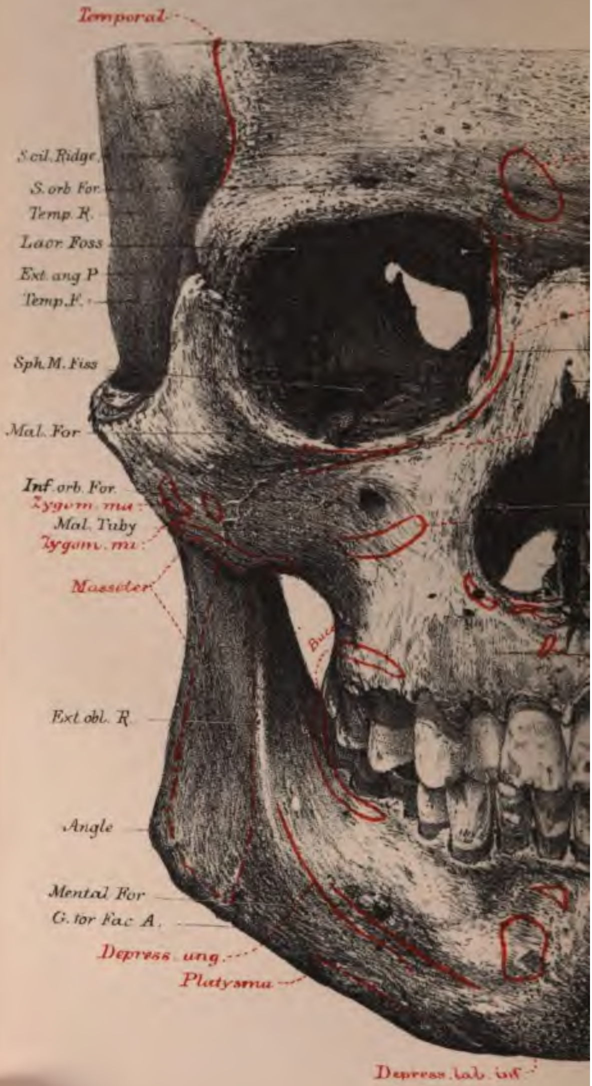
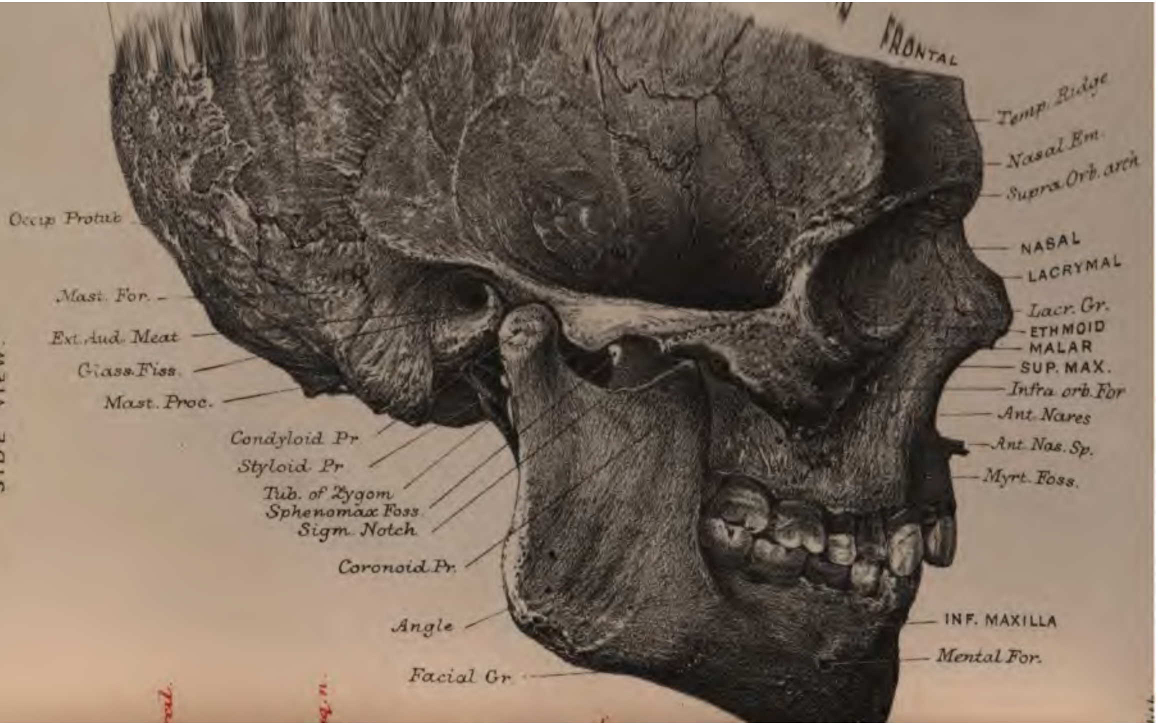


PLATE XXI.

FACE (*right half*)
SIDE VIEW.



Back view. In this we notice the arch formed by the vault, the back of the *sagittal suture*, the *lambdoidal suture* with frequently its Wormian bones, the *exterior occipital protuberances*, *crest*, and *curved lines.*

Under view, or *base of the skull* (Plate XX). After noticing the arch formed by the body of the lower jaw, which gives great strength and protection against injury from blows on the chin, this bone should be removed and the base examined without it. The outline is now formed by the front of the hard palate, the zygomatic arch, mastoid processes, superior curved lines, and exterior occipital protuberance. The bones seen within this outline are the superior maxillary bones, malar, temporal, occipital, sphenoid, palate, and vomer. The foramina, grooves, processes and markings are very numerous, and it will be best to take (*a*) those things seen in the middle line; (*b*) those seen in certain lines drawn transversely across the base; (*c*) those seen in other parts of the base.

(*a*) In the middle line we find from before backwards

(1) The *suture* between the palatine plates of the two upper jaws and the two palate bones with

(2) The *anterior palatine foramen* behind the central incisor teeth.

(3) The *posterior nasal spine*, and

(4) The *vomer.*

(5) The *basilar processes* of the sphenoid and occipital fused together, and on the fused process,

(6) A small tubercle, the *pharyngeal spine.*

(7) The *foramen magnum*, behind which is

(8) The *exterior occipital crest*, leading to

(9) The *exterior occipital protuberance.*

(*b*) Now draw a line across the base of the sk immediately in front of the mastoid processes, t being the axis upon which the movements of flex and extension of the head are performed. In t line we find

(1) The *auricular fissure*, with the *external audit meatus* in front and the *mastoid process* behind.

(2) The *stylo-mastoid* foramen, with *styloid* *vaginal processes* in front, and the *digastric* and *occip grooves* behind.

(3) The posterior margin of the *jugular foram* with the *jugular fossa* of the temporal bone in fro and the *jugular process* of the occipital behind, with rough surface for the rectus lateralis M.

(4) The *condyle*, with the *anterior condyloid fora* (9th nerve) and the inner end of the jugular foran (8th nerve) in front, and the *posterior condyloid fora* behind for a small vein.

(5) The anterior margin of the *foramen magnum.*

Now carry another line across the base from tubercle of one zygoma to the other; it will be ab an inch or an inch and a quarter in front of the l line, and will pass through the following:

(1) The *tubercle of the zygoma.*

(2) The *articular eminence* in front of the glen cavity.

(3) The *foramen ovale* for the 2nd division of the nerve and small meningeal artery, with the spin process of the sphenoid and the *foramen spinosum* the great meningeal artery behind and external to

(4) The groove for the *Eustachian tube* between petrous and sphenoid, with the *scaphoid fossa* and root of the pterygoid plates in front, and the tip of petrous bone behind.

(5) The front edge of the *foramen lacerum medium*, with the anterior opening of the *carotid canal* behind it, but situated nearer the interior of the skull.

(6) *Basilar process*, behind the base of vomer.

(*c*) Between these two lines are placed the various things seen on the under surface of *petrous* and *squamous* bones, the *spine of sphenoid*, and the *basilar processes* with the pharyngeal spine. Notice that the petrous bone is wedged into the base and is very rough, that its anterior and posterior margins would, if prolonged, meet about the posterior edge of the vomer, and form an angle of about 30°, so that if a transverse and an antero-posterior line be drawn to the back of the vomer, the right angle formed between them would be divided into three equal parts by the anterior and posterior edges of the petrous bone; the anterior line would run through the *Glasserian fissure* and the *spheno-petrosal suture* and the groove for the *Eustachian tube;* the posterior line through the *occipito-petrosal suture* and the *jugular foramen*. Another point of great importance to notice in this region is the relation of the carotid to the jugular foramen, and of these to the anterior condyloid and that portion of the jugular through which the 8th nerves pass. The *carotid foramen* is in front of, and internal to the *jugular fossa*, separated only by a thin plate of bone, in which is the *canal for Jacobson's nerve;* the inner and anterior part of the jugular foramen transmits the 8th nerves (glosso-pharyngeal alone, pneumogastric and spinal accessory together), and is directly on a level between the carotid foramen and jugular fossa. Moreover, the *anterior condyloid* foramen, which transmits the 9th, or hypoglossal nerve, grooves the bone to reach the same point—the level between carotid and jugular

foramina. What wonder, then, if the glosso-ph geal, pneumogastric, spinal accessory, and glossal nerves often pass between carotid arter jugular vein, the pneumogastric and hypog almost always, the others sometimes? What w too, if the glosso-pharyngeal gives off a tyn branch (Jacobson's nerve) which perforates the between the two vessels, and the pneumogast auricular branch (Arnold's nerve) in the jugular

In front of the anterior of the two transvers we see the *hard palate* with the *posterior palatine f* close to the *tuberosity* of the palate bone, which i forming part of the *pterygoid fossa*. The in *pterygoid plate* has its *hamular* process for the palati, unless, as is frequently the case, it is l off; it forms the lateral boundary to the po nares. The *external plate* projects outwards base of the *vomer* is seen to be fitting under the *processes* of the internal plates. Outside the s the palate we come to the *zygomatic arches* and *matic* and *temporal fossæ*, which have already seen in the side view.

Behind the posterior line are seen those ma and foramina belonging to the outer surface mastoid and occipital bones, the *inferior curv* leading to the *jugular process*, and those stru already mentioned in speaking of the line.

*Interior of skull.**—If the skull-cap be remov see the interior of the vault and of the base.

* What a curious resemblance may be traced bet transverse section of a tunnel, and that of the skull (F It is of course of great importance that the constructio skull should be such as to protect the contents from either from sudden or steady pressure.

Vault.—This shows the oval outline with its greatest width about the parietal eminences, the median groove for the *longitudinal sinus* more marked behind, with several *depressions* on either side for Pacchionian bodies, the depressions corresponding with the *parietal eminences* and *grooves* for the middle meningeal artery.

Base.—The first feature which is noticeable is the great unevenness of surface compared with the smooth vault above; but this is more apparent than real, for in the natural state the base is covered over by dura mater, so as to diminish the inequalities and partially close the openings which are seen in the dry skull. In fact, beyond the sharp outlines of the three fossæ, there are not naturally any irregularities at the base, but inasmuch as the nerves leave the brain below, this organ is more fixed below, and therefore more liable to injury at the base when the head is shaken; and the existence of the three sharply-defined fossæ adds to the chances of injury occurring here. The base of the skull is mechanically arranged for great strength and elasticity. Firstly, there are strong buttresses for lateral pressure in the shape of the petrous bones, pyramidal masses leading from the outer wall and resting against the middle bar formed by the basilar process; but it may be noticed that they are only apposed, or lying together without dovetailing or otherwise locking

Fig. 63.

Transverse section of skull, showing tunnel-like arrangement of vault.

together. Two other buttresses run in from the to the anterior curved edges of the middle f curved for greater elasticity, and these run t middle bar, now the hollow body of the sphenoi

Next there are the groins, resembling those on the roofs of our Gothic buildings. The larg these is the raised and thickened borders of the g for the longitudinal sinus (Fig. 64), which runs flange from front to back, from the ethmoid t foramen magnum. Another is that of the lateral (Fig. 65), which runs horizontally from the back one petrosal buttress to the other through the pital protuberance.

Next notice the central bar. Trace it fron condyles where it forms the basilar process, thic strong, but soon becomes hollowed out for ligh

Fig. 64.

Antero-posterior section of skull, showing curved bar supporting an arched vault.

as it is traced to the body of the sphenoid, an ethmoidal vertical plate: here it is still a c defined mass, and supports on its upper and end the arched groin of the vault just referre Trace it backwards, and notice it splittin

surround the foramen magnum, but still forming a strong, thick, bony ring, uniting again behind to receive the inner occipital crest, which is the posterior end of the groin of the vault. Or take it, if you will, to the level of the occipital protuberance where the horizontal groining runs, and consider that the central curved bar runs from ethmoid to occipital protuberance, for the ring surrounding the foramen is continued on as the crest, as can be verified by holding the skull up to the light. That this central

Fig. 65.

Diagram of base of skull, showing central bar with curved buttresses springing from it.

bar is a curved one is evident, the concavity being upwards; and we see the advantage that is gained, for elasticity is obtained besides strength, and elasticity is of great moment considering the constant exposure of the vault to pressure by falls and blows. And to allow of this elasticity being brought into play it would seem that the lateral buttresses (petrous bones) are only laid against the bar and not united with it.

Compare with the arrangement as regards stre
the inverted arches built in below windows where
pressure exists above; but in the case of the sk
is not merely strength that is wanted but elast
to prevent the communication of shocks to so del
an organ as the brain.

If we examine now for the purpose of seeing
openings, processes and markings are seen in the
we may notice the three fossæ, the posterior bein
largest, and occupying more than half the m
line. The middle fossa is the smallest from b
backwards, its extent being confined to the pitu
fossa in the middle line.

In the anterior fossa, bounded in front by
frontal arch, behind by a sharp edge, we notic
in the middle line from before backwards

(1) The *crest* for the superior longitudinal
and falx major of dura mater.

(2) *Foramen cæcum* for a vein and dura mater.

(3) *Crista galli* continued backwards in

(4) The *crest* of the ethmoid.

(5) Sometimes the outline of the *ethmoidal spi*
sphenoid.

(*b*) On each side we find (6) the vertical portio
the frontal.

(7) *Supra-orbital plates*, with the markings o
convolutions.

(8) The *olfactory foramina*, in three sets for
olfactory filaments.

(9) The slit by the side of the crista galli fo
nasal nerve.

(10) The opening of the *anterior ethmoidal for*
for the transmission of the same nerve.

(11) The *olfactory groove* on each side of the cr

(12) *The lesser wings of the sphenoid* projecting backwards, as

(13) *The anterior clinoid processes* for a process of dura mater to the other clinoid process, which is sometimes bony, and serves to bind down the internal carotid artery.

The sharp edge between the anterior and middle fossæ is formed by the lesser wing of the sphenoid and the frontal, and fits into a fissure in the brain (Sylvian fissure), between the anterior and middle lobes.

The middle fossa extends from this edge to the posterior upper margin of the petrous bone, and is unlike the other fossæ in being narrowest from before backwards in the middle line. It lodges the middle or temporal lobe of the brain. In it are seen

(*a*) In the middle line

(1) *The optic grooves,* sometimes uniting in front of

(2) *The olivary eminence,* upon which the optic commissure lies.

(3) *The sella turcica* or *pituitary fossa* for the pituitary body, an appendage of the brain, supposed at one time to secrete pituita or nasal mucus.

(*b*) On each side are seen the

(4) *Optic foramina* passing through the lesser wing of the sphenoid for the optic nerve and ophthalmic artery.

(5) *Middle clinoid processes,* sometimes united by a spicule of bone with the anterior, and indicating the position of the internal carotid artery.

(6) *Groove for the cavernous sinus* on the side of the body of the sphenoid, leading forwards to the

(7) *Sphenoidal fissure,* or anterior lacerated foramen, for the passage into the orbit of the 3rd and 4th, the

ophthalmic division of the 5th and the 6th nerves with the ophthalmic vein

(8) Behind, and external to the lowest angle of the sphenoidal fissure is the *foramen rotundum* for the 2nd division of the 5th nerve. Behind and external to this is the

(9) *Foramen ovale* for the 3rd division of the 5th. Again, behind and external to this is the

(10) *Foramen spinosum* for the great meningeal artery, with a deep groove running from it to the squamous bone, and branching.

(11) Internal to the foramen rotundum is the small *foramen Vesalii* for a vein.

(12) At the posterior end of the cavernous sinus is the *foramen lacerum medium*, a space naturally filled with fibro-cartilage, and, as it were, compelling the carotid artery to find its way into the interior of the skull through

(13) The *carotid canal*, here seen to be opening at the tip of the petrosal bone.

(14) The *hiatus Fallopii* is seen as a groove or canal on the upper surface of the petrous portion, and nearer the tip

(15) A depression for the Gasserian ganglion, while

(16) The elevation, owing to the superior semicircular canal, is situated near the junction of the petrous with squamosal portions.

The margin between the middle and posterior fossæ runs forwards and inwards on the petrosal buttress and gives attachment to the dura mater, which here stretches over the cerebellum in the posterior fossa, and is called the tentorium cerebelli. The margin is grooved for the superior petrosal sinus, and is continuous with the upper raised edge

of the groove for the lateral sinus on the mastoid, parietal, and occipital bones. The foramen magnum occupies the centre of the fossa.

(*a*) In the middle line are seen

(1) *Basilar process*, projecting above as a plate at the back of the sella turcica, and marked below by the

(2) *Basilar groove* for the medulla oblongata.

(3) *Foramen magnum* for the preservation of the connexion of the spinal cord and brain, and for the passage of the vertebral artery, a plexus of veins around the spinal cord, the spinal membranes, and some of the ascending roots of the spinal accessory nerve.

(4) The *interior occipital crest* leading to

(5) The *interior occipital protuberance*, with *Torcular Herophili* to the right side of it.

(*b*) On either side are seen

(6) *Posterior clinoid processes* overhanging the pituitary fossa.

(7) The *groove for the inferior petrosal sinus* between the petrous bone and basilar process.

(8) *Interior auditory meatus* for the facial and auditory nerves.

(9) A cleft or depression for the dura mater behind this, and

(10) The *aqueductus vestibuli* below the latter.

(11) The *posterior lacerated* or *jugular foramen* with its inner part somewhat distinct for the glosso-pharyngeal, pneumogastric, and spinal accessory nerves, and its outer large for the jugular vein, the right being usually larger than the left. The foramen is continuous with the

(12) *Groove for the lateral sinus* on the mastoid portion.

(13) The *Mastoid foramen* opens into the sin
generally in the most posterior angle of the masto

(14) Inside the foramen magnum is the opening
the *anterior condyloid foramen* for the 9th nerve.

(15) On each side of the crest may sometimes
seen a groove for the occipital sinus, and

(16) In the cerebellar fossæ sometimes there
grooves for a posterior meningeal artery.

THE FOSSÆ ON THE EXTERIOR OF THE SKU

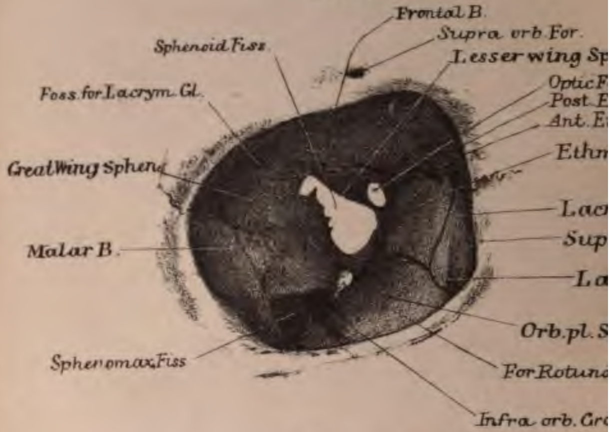
These are irregular hollow spaces formed by
junction of certain bones, and have been alre
referred to in examining the exterior. They may
be noticed separately. They are five in numbe
orbital, nasal, temporal, zygomatic, and sphe
maxillary.

Orbital fossæ (Plate XXII). Situated between
forehead and cheek, they form two conical spa
whose apices are directed backwards and rat
inwards, and are filled in the natural state by the
and its muscles, vessels, nerves, lachrymal gland,
fat. Each is made up of seven bones—frontal, ethm
sphenoid (these being median bones), and the supe
maxillary, lachrymal, palate, and malar.

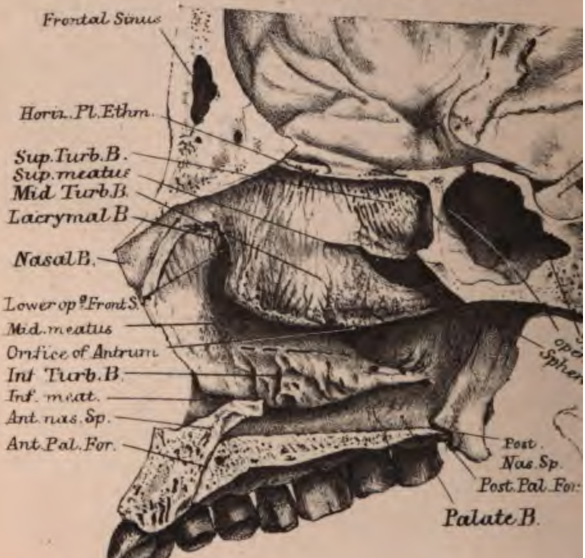
Each may be said to have four walls. In the *r*
which is formed by the frontal bone and the le
wing of the sphenoid, we find the *fovea trochlearis* w
its tubercle for the pulley of the superior oblique M
the inner side, the *lachrymal fossa* for the lachry
gland towards the outer side, and the *supra-orb*
foramen or canal in the middle. The *floor* is form
by the superior maxillary and palate bones,
in front by the malar; in it we see the *infra-orb*

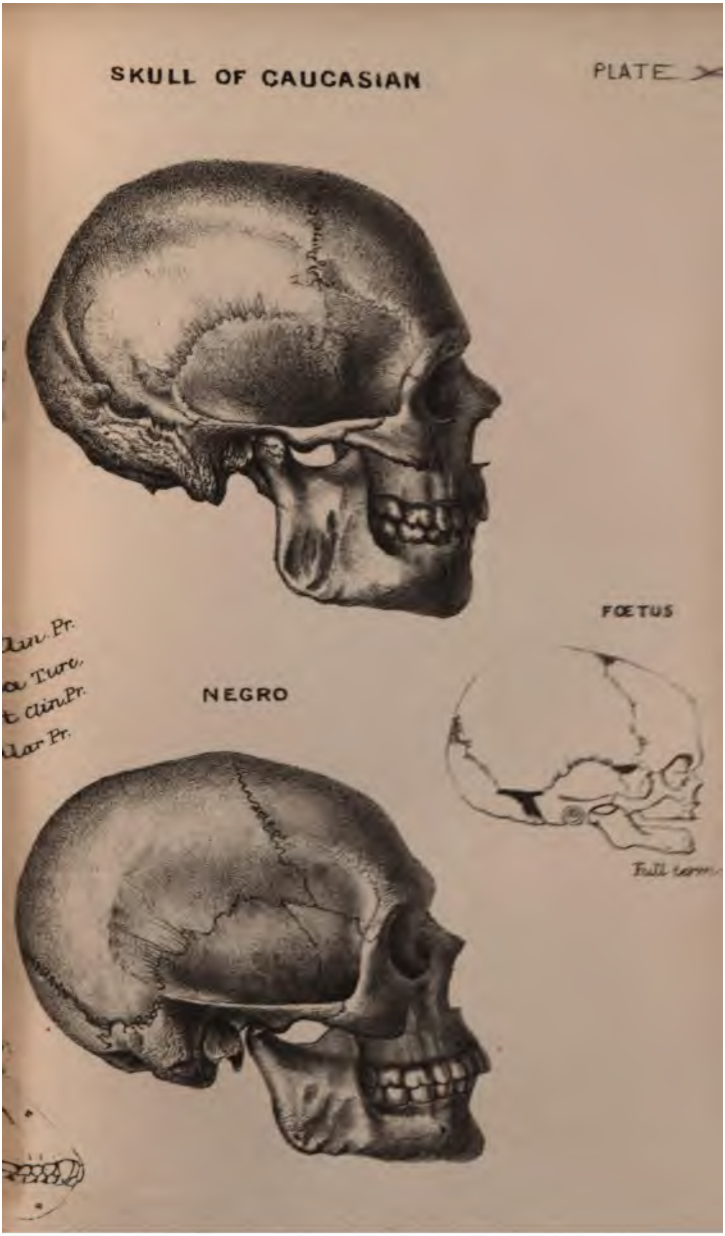
ORBIT (*right*)

FRONT VIEW



NASAL FOSSA (*right*)




SKULL OF CAUCASIAN
PLATE
FŒTUS
NEGRO

groove for the nerve and vessels of that name, and just outside the lachrymal groove, a depression for the inferior oblique M., the *tubercle of the lachrymal bone* at the edge of the groove, and lastly, the sutures of the three bones. The *inner wall* is formed by the nasal process of the superior maxillary, lachrymal, ethmoid, and a small piece of the body cf the sphenoid bones; in it we see the *lachrymal groove*, whose direction is downwards, and then slightly backwards and outwards, and this is of importance to remember in passing a lachrymal probe: in this wall also are seen the *anterior* and *posterior ethmoidal foramina* naturally occupied by vessels, and the former for the nasal nerve. The *outer wall* is formed by the malar and the great wing of the sphenoid, and presents the openings of one or two *malar canals*. In the angle between the outer and the lower wall is the *spheno-maxillary fissure* which transmits the infra-orbital vessels and nerves and the ascending branches from the spheno-palatine ganglion which lies in the fossa below.

The apex is formed by the *optic foramen* and the *sphenoidal* fissure, the former transmitting the optic nerve and ophthalmic artery; the latter the 3rd, 4th, 1st division of 5th, 6th nerves, and ophthalmic vein.

This fossa receives therefore nine openings—optic, sphenoidal fissure, spheno-maxillary fissure, supra-orbital, lachrymal, infra-orbital, two ethmoidal, and malar.

Nasal fossæ (Plate XXII). This should be examined in a longitudinal section of the skull. It is situated in the middle of the face, opening in front by means of the anterior nares at the nostrils, behind by the posterior nares into the back of the mouth. In shape it is irregular, but essentially four-

sided either in side view or in section, the outer wall bearing three scroll-like bones (turbinated), each overhanging a channel (meatus) into which various cavities open, the inner wall being formed by the median septum.

The number of bones helping to form each cavity is ten—three belong to the cranium and are median (frontal, sphenoid, ethmoid), the rest all facial, one median (vomer), and six in pairs (nasal, lachrymal, superior maxillary, inferior turbinated, palate, sphenoidal turbinated). All the bones of the face therefore except the lower jaw and the malar are seen in this fossa.

The *upper wall* or *roof* is formed by the nasal bones, nasal spine of the frontal, horizontal or cribriform plate of the ethmoid, and the body of the sphenoid; the front and back parts are sloping. In the roof are seen the *nasal crest* and *spine*, the groove for the nasal nerve, the *olfactory foramina* arranged in three sets, the *alæ of the vomer* articulating with the body of the sphenoid; notice especially the thinness of the cribriform plate, how easily it could be perforated from below, and how bleeding at the nose might attend a fracture of the base of the skull through this bone.

The lower wall or *floor* is formed by the palatine processes of the superior maxillary and palate bones. It is concave from side to side, continuous with the inferior meatus, flat from before backwards, widest in the middle, presents only the upper opening of the *anterior palatine foramen* for the anterior palatine artery and nerve.

The inner wall or septum is formed by the nasal crest and the nasal spine of the frontal, the vertical plate of the ethmoid, the vomer, the rostrum

of the sphenoid, the crest of the superior maxillary and the palate bones, and in recent state by the median cartilage of the nose. This septum is smooth, and is usually somewhat out of the true middle line, just as the nose itself is usually not truly median. On it are seen grooves for the olfactory nerves, and one large groove or canal for the naso-palatine nerve and vessels. The ethmoidal portion is covered with olfactory mucous membrane.

The outer wall is formed by the nasal bones, the nasal process of the superior maxillary, the lachrymal, the ethmoidal turbinated, the inferior turbinated, the palate, the pterygoid processes. On it we find the thin turbinated bones, the upper placed most posteriorly, the lower extending furthest forwards. Each overhangs its own meatus, and the upper two are marked by small parallel grooves for the olfactory nerves, the lowest being irregular on its surface.

In relation with the upper meatus we find (1) the *posterior ethmoid cells* opening into it, (2) the *sphenoidal cells* opening behind it, (3) the *spheno-palatine foramen* opening behind it and naturally filled by nerves and vessels.

In relation with the middle meatus we find (1) the *anterior ethmoidal cells* opening into it, in company with (2) the *infundibulum* from the frontal sinus, (3) behind these the *antrum of Highmore* opens by a large orifice in the skeleton, but much diminished in size by the thick mucous folds in the recent state.

In relation with the lower meatus we find (1) lower end of the *lachrymal groove* opening into it in front, (2) the *Eustachian tube* opening behind it on the same level so that a probe can be readily passed along the floor of the nose and into the tube by directing the

point upwards and outwards. (3) The *anterior palatine foramen* opens into the lower wall of the fossa below, and internal to the meatus.

In the outer wall notice the delicate structure of the spongy bones, and how easily violence may injure them, either by a blow or by forcible evulsion of a polypus from this surface. Observe also how the lachrymal bone sends down a small process, which appears in this fossa. Sometimes a fourth meatus exists above the superior turbinated.

The anterior and posterior boundaries are formed by the openings called anterior and posterior nares, the two anterior forming a heart-shaped outline.

The sets of openings into each nasal fossa will therefore be twelve—anterior and posterior nares, anterior and posterior ethmoidal cells, infundibulum with the former, antrum, lachrymal groove, anterior palatine foramen, sphenoidal cells, spheno-palatine foramen, foramen for the nasal nerve, and olfactory foramina.

Temporal fossa (Plates XXI. XXII.). Formed by five bones—temporal, parietal, frontal, sphenoid, and malar. It is limited above by the temporal ridge, and below by the temporo-zygomatic ridge on the sphenoid, and by the arch of the zygoma. The fossa gives attachment throughout to the temporal muscle, and by its boundary to the temporal fascia: it is marked sometimes by grooves for the deep temporal artery.

Zygomatic fossa. An irregularly-shaped space, situated below the temporal fossa, on the outer side of the superior maxillary bone and external pterygoid process. It is formed by five bones—superior maxillary, palate, sphenoid, temporal, with the zygomatic arch. It consists of two parts—an anterior or larger part separated from the posterior by the pterygo-

maxillary fissure; the posterior includes the external pterygoid plate and part of the great wing, with the origin of the external pterygoid muscle. The anterior part is convex, and perforated by the posterior dental foramina.

The openings into this fossa are therefore few, being only the posterior dental canals, and the pterygo-maxillary fissure, or triangular space between pterygoids and superior maxilla.

Spheno-maxillary fossa.—A small triangular fossa found behind and below the back of the orbit, giving room for an important ganglion (Meckel's), and for vessels and nerves. It is formed by three bones: sphenoid, superior maxillary, and palate. *Base* or upper wall is formed by the body of the sphenoid. *Posterior wall* by pterygoid processes. *Anterior wall* by the back of the upper maxilla. *Inner wall* by the vertical plate of the palate bone. Continuous with the fossa at three of its angles are clefts or fissures, the *spheno-maxillary* running from its anterior angle and communicating with the orbit, the *pterygo-maxillary* running downwards and outwards, and the *sphenoidal* running forwards into the orbit.

The openings into the fossa on its posterior wall are the *foramen rotundum*, transmitting the 2nd division of the 5th nerve towards Meckel's ganglion; *Vidian canal*, transmitting Vidian nerve and vessels; *pterygo-palatine canal* for nerves and vessels of same name. On the inner wall the *spheno-palatine foramen* transmits vessels and nerves of that name to the nose. Below at the apex is the *posterior-palatine canal* and one or two *accessory palatine* foramina. All these canals transmit nerves from Meckel's ganglion and branches from the third portion of the internal maxil-

lary artery. There are, therefore, six canals and three fissures connected with this fossa.

Cranial sutures.—Connecting the cranial bones together are twenty sutures, which have received special names in many instances, but are best named according to the bones involved.

(1) *Inter-parietal* or *sagittal*, deeply dentated between the parietal bones, and continued forwards in some cases as the frontal suture between the two halves of the frontal. This is always present in young children, where also the inter-parietal suture ends at the anterior and posterior fontanelles; near the posterior end we see one or more parietal foramina, and sometimes at the anterior end a Wormian bone.

(2) *Fronto-parietal* or *coronal*, at right angles to the sagittal, passes across the top of the cranium, from one great wing of the sphenoid to the other; the frontal lies on the parietal bones above, but is overlaid by them below.

(3) *Occipito-parietal* or *lambdoidal* is triangular, and extends from one mastoid portion to the other; it is deeply dentated and usually contains Wormian bones.

(4, 5) *Masto-parietal.*

(6, 7) *Temporo-parietal* or *squamous.*

(8, 9) *Spheno-parietal*, forms a continuous suture between the parietal and the temporal and sphenoid, extending from the coronal to the lambdoidal suture; it is thin and overlapping in the middle, slightly dentated behind, and sometimes presents a Wormian bone.

(10) *Basilar*, between the sphenoid and occipital bones, is cartilaginous in the child, and disappears in the adult when the sphenoid and occipital have to be sawn asunder in order to separate them.

(11, 12) *Petro-occipital*, between the petrous bone

and occipital, the bones being apposed with a thin layer of cartilage between.

(13, 14) *Masto-occipital*, slightly dentated, often presenting a mastoid foramen.

(15, 16) *Petro-sphenoidal*, between the petrous and the great wing of the sphenoid; the bones being simply apposed a sutura apposita or harmonia is formed.

(17, 18) *Squamo-sphenoidal*, between squamous and the great wing of the sphenoid, a sutura limbosa, the bones being cut obliquely and serrated.

(19) *Sphenoidal*, between the sphenoid and the bones in front—viz., frontal, ethmoid, and sphenoidal turbinated.

(20) *Ethmoidal*, or *fronto-ethmoidal*, between the broad margin of the frontal around the ethmoidal notch and the upper cells of ethmoid, and in it are the cells and the ethmoidal foramina.

Cranio-facial Sutures—

(1, 2) *Fronto-nasal*, horizontal between the nasal spine of the frontal and the nasal bones.

(3, 4) *Fronto-maxillary*, between the internal angle of the frontal and the nasal process of the superior maxillary.

(5, 6) *Ethmoido-lachrymal*, a thin perpendicular suture.

(7, 8) *Ethmoido-maxillary*, a horizontal thin suture, seen like the last in the orbit on its inner wall.

(9, 10) *Fronto-malar*, thick, between the external angular process of the frontal and the frontal process of the malar.

(11, 12) *Spheno-malar*, behind the latter in the temporal and orbital fossæ.

(13, 14) *Temporo-malar*, oblique, bevelled, forming part of the zygomatic arch.

(15, 16) *Spheno-palatine,* seen in the orbit and in the spheno-maxillary fossa.

(17, 18) *Spheno-vomeral,* an invaginated articulation or schindylesis between the alæ of the vomer and the body of the sphenoid.

(19, 20) *Ethmoido-turbinal,* between the ethmoid and the ethmoidal process of the inferior turbinated bone.

(21, 22) *Ethmoido-palatine,* seen in the orbit between the orbital process of the palate and the os planum of the ethmoid.

Facial Sutures.—These have already been de-

Fig. 66.

Veins of diploë.

scribed with the several facial bones, and need no special description.

Substance of the cranial bones (Fig. 66).—The diploë is traversed by venous canals, which can be shown by filing off the outer table. They are irregular, but are arranged in three sets : frontal, tem-

ral, and occipital. The frontal and temporal open ternally, the occipital into the lateral sinus. After juries to the head these veins may become inflamed id give rise to the disastrous effects of phlebitis— very serious complication in bone injuries.

FONTANELLES.—Plate XXII.

These are the larger membranous spaces found between adjoining skull-bones, when ossification has not yet been completed, and take their names from the fact that the brain can here be felt to pulsate fountain-like. There are two large fontanelles situated the middle line, and called anterior and posterior, and there are four smaller ones, two on each side, corresponding with the lower anterior and posterior angles of the parietal bones.

The anterior fontanelle is large, diamond-shaped, owing to the four sides from which ossification is proceeding. It usually closes about the first or second year after birth.

The posterior fontanelle is smaller, more triangular, ossification proceeding from three centres; it is situated at the junction of the occipital with the parietal bones. It is usually closed a few months after birth.

The lateral fontanelles are small, the anterior being situated between the parietal, frontal, sphenoid, and temporal; the posterior between the parietal, occipital, and mastoid; they are both closed shortly after birth, and they both present not uncommonly one or more Wormian or inter-sutural bones.

The presence of the fontanelles allows, no doubt, of much more ready adaptation of the brain to the pressure to which it is exposed during its passage through the pelvis. The brain being inelastic and of great delicacy of structure, provision must be made for its protection, and at the same time the maternal parts have to be protected against injury.

The sutures, especially those seen at the vertex, provide for a certain amount of overlapping, and a consequent moulding of the head of the child to the surface against which it is forced; the firmness and unyielding nature of the base protect the most important part of the brain from injury, while the fontanelles by their yielding allow of the temporary disturbance of the upper or unattached portion of the brain.

Cases are not uncommon in which the fontanelles do not close at the usual time, but remain even permanent as fibrous structures. These are cases in which development has been interfered with at these spots, generally in consequence of disease. Tubercle of the brain is one of the commonest causes of this want of development. A child should always be examined as to the condition of the fontanelles, for it is a sign of unhealthy condition if they be abnormally open.

INTERIOR OF THE TEMPORAL BONE.—PLATE XXIII.

If a section be made through the temporal bone, from the external to the internal auditory meatus, the petrous bone is seen to be perforated by numerous cavities and canals. If the section be made carefully, and the bone cleared away above, the arrangement of these cavities and canals can be demonstrated, and another section may be made as in Plate XXIII., by sawing vertically along the line of the Eustachian tube.

It will then be seen that there are three parts into which the general track is divided—(1) external auditory meatus, leading from outside to the membrane; (2) tympanic cavity, between the membrane and a perforated inner wall; (3) internal ear, including (*a*) a central cavity, the vestibule; (*b*) a spiral tube in front of this, the cochlea; (*c*) three curved canals, the semicircular canals springing from the upper and back part of the vestibule; and lastly (*d*) the internal auditory meatus.

External auditory meatus is trumpet-shaped, its lower wall longer than its upper, raised in the middle, where it is narrowest, so that a hollow exists between the eminence and the membrana tympani, or membrane which closes its inner end; the meatus is directed inwards and slightly forwards, and in the natural state is prolonged as a cartilaginous tube outside; over the orifices of this the tragus projects as a lid. The Glasserian fissure runs along the upper and front surface, and only a thin plate of bone separates

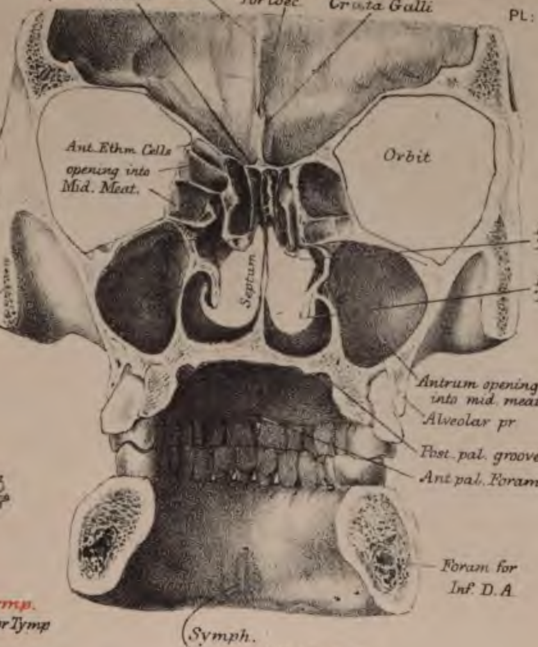
M = *Mallens*
I = *Incus*
O = *Orbic*
S = *Stapes*

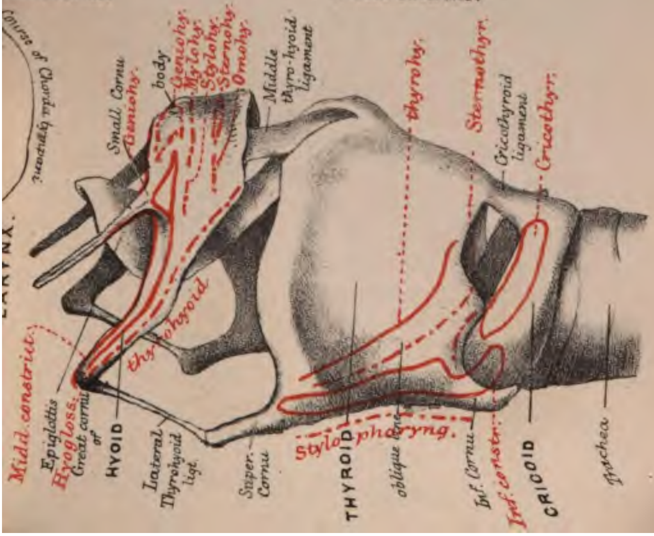
1. *Head of mallens attached to upper wall of Tympanum*
2. *Handle of mallens running to middle of membr. tympani*
3. *Proc. gracilis of Mall. in Glasserian Fiss.*
4. *Short proc. of Mall.*
5. *Long proc. of Incus curved at end & artic. with orbicular*
6. *Short pr. of incus in mastoid cells.*

RIGHT EARBONES ARTICULATED

SECTION *through* ORBITS, ANTRUM, NOSE, *and* MOUTH.

PL: XXIII.





the meatus from the glenoid cavity, so that injury to the meatus may result from a blow upon the chin, acting through the articulation of the lower jaw. Below and behind the Glasserian fissure the curved plate of bone forming the wall results from the development of a ring nearly surrounding the membrane, and easily seen in the fœtus.

(2) **Middle ear or tympanum** is the flattened irregular space between the membrane and the honeycombed bone inside: it possesses certain little bones or ossicles, and communicates with the pharynx by means of the Eustachian tube. Examining this cavity we find it is limited by six sides. On the *outer wall* in the recent state is the *membrana tympani*, fitted into a grooved ring, which is incomplete above; the membrane is placed obliquely at an angle of about 45°, so that its lower edge projects inwards, and is not flat but concave outwards, owing to the handle of the malleus being in its substance, and fixing it; the tip of this handle can be seen through the thin membrane in the healthy man, as a prominent reflecting spot in the centre of the membrane. In the *outer wall* are three openings—(*a*) *iter chordæ posterius*, close behind the edge of the membrane opposite its centre, for the entrance of the chorda tympani nerve; (*b*) *Glasserian fissure*, giving transmission to the laxator tympani M., and a process of the malleus (processus gracilis); (*c*) *iter chordæ anterius*, or canal of Huguier, just above the Glasserian fissure, for the exit of the chorda tympani nerve. The membrane is for the purpose of collecting and communicating vibrations of sound from the external to the internal ear, through the chain of ossicles.

Inner wall not vertical, but looking outwards and

downwards, perforated by (*a*) *fenestra ovalis*, an oval opening leading to vestibule, and filled by the base of the stapes; (*b*) *fenestra rotunda*, an irregular opening below the ovalis and leading to the cochlea, but closed by membrane. Between these two openings is a prominence, the *promontory*, which is really due to the bulging of the first turn of the cochlea; it overhangs the fenestra rotunda very much, and is marked by grooves and canals for nerves (tympanic plexus). One groove enters the carotid canal, and allows of the junction of a branch of the tympanic with the carotid plexus of the sympathetic; another passes to the jugular foramen, and transmits the small superficial petrosal to the otic ganglion; and a third transmits a branch to the great superficial petrosal of the Vidian.

Above the fenestra ovalis there is a horizontal eminence which, when traced backwards, is seen to pass perpendicularly downwards behind the fenestra ovalis; it is the *aqueductus Fallopii*, and carries the facial nerve to the stylo-mastoid foramen below. In front of the descending portion is a small prominence, the *pyramid*, perforated at the top by an opening for the tendon of a muscle, the stapedius.

Posterior wall wider above than below. It shows the openings of the *mastoid cells* or cavities in the mastoid portion of the bone, which naturally contain air.

Anterior wall presents two long canals, the lower being the larger. The upper or *canal for the tensor tympani* lodges that muscle, and at its ending in the tympanic cavity forms a small perforated prominence, the *anterior pyramid*, through which the tendon of the muscle runs. The lower canal is the bony part of the *Eustachian tube*, and is smaller towards the base of the

skull, where it is continued as the cartilaginous tube, which opens behind the inferior meatus into the nasal fossa. Between the two canals is the plate of bone called *processus cochleariformis.* It must be noticed that the Eustachian tube is only separated from the carotid canal by the thinnest possible plate of bone. Hence injury or disease may extend from one to the other.

Lower wall narrow, only separated from the jugular fossa by a thin plate of bone, hence it is possible for disease to extend from the tympanic cavity to the jugular vein, and a patient may die of bleeding from this vein as the result of ulceration proceeding from the tympanum.

Upper wall thin, separating the tympanic from the cranial cavity; disease may extend from the tympanum through this wall to the membranes of the brain.

OSSICLES OF THE EAR.—PLATE XXIII.

Synonyms: *G.* Das Beinchen. *Fr.* Osselet.

Four bones are articulated together in a curious form, and cross the cavity of the tympanum from the membrana tympani to the fenestra rotunda. They are in order from without inwards—malleus, incus, orbicular, and stapes.

MALLEUS.

Synonyms: *E.* Hammer. *G.* Das Hammer. *Fr.* Le marteau.

It is supposed to be like an ancient hammer, and consists of a head, neck, and three processes. *Head* is the largest part, rounded, one side of it fitting into the concavity of the incus, suspended by a ligament from the roof of the tympanum. *Neck* is the constricted part below the head. *Handle* is embedded in

the membrana tympani, curved forwards at the tip, which corresponds with the centre of the membrana tympani, the lower edge of the handle being almost horizontal, owing to obliquity and concavity of the membrane. *Processus gracilis* running forwards, long, slender, bent, lies in the Glasserian fissure, through which it was continued in the fœtus as Meckel's cartilage in the inferior dental canal to the symphysis of the lower jaw, where it unites with the cartilage of the opposite side; the laxator tympani M. runs in the Glasserian fissure and is attached near the root of this process. *Processus brevis*, a small tubercle which projects from near the junction of the handle and the processus gracilis, makes the lower border of handle more horizontal, lies in contact with membrana tympani, and gives attachment to the tensor tympani M.

INCUS.

Synonyms: *E.* Anvil. *G.* Der Amboss. *Fr.* L'enclume.

Resembles a bicuspid tooth with divergent fangs, was named from a fancied resemblance to an anvil, possesses a body and two processes. *Body* flattened, one angle prominent and rounded, one side (anterior) concave to receive the head of the malleus. *Short process* projecting directly backwards, attached near the orifice of the mastoid cells. *Long process* nearly parallel with the handle of the malleus, but curved upwards at the tip, where it is capped by the orbicular bone.

ORBICULAR BONE.

Synonyms: *G.* Das runde Ohrbeinchen. *Fr.* L'orbiculaire. *L.* Lenticulare.

The smallest bone in the body, sometimes looked upon as only an epiphysis to the incus.

STAPES.

Synonyms : *E.* Stirrup-bone. *G.* Der Steigbügel. *Fr.* L'étrier

Stirrup-shaped, runs at nearly right angles to the direction of the handle of the malleus, and therefore inclined upwards and outwards to be fitted into the fenestra ovalis. *Head* is a small boss, sometimes hollow with a central column (as in the specimen from which the engraving is taken); it articulates with the orbicular, and is slightly constricted below to form a *neck*, into which the stapedius M. is inserted. *Branches* grooved on opposed surface, not quite equal, the posterior branch being more bent. *Base* oval, fitting into the foramen ovale, lower edge straight, upper curved, margin grooved.

(3) **Internal ear.**—This includes three parts: vestibule, semicircular canals, and cochlea, which together constitute the bony labyrinth. The vestibule occupies a median position, the cochlea lying in front and the semicircular canals mainly behind.

VESTIBULE.

Synonym : *G.* Der Vorhof.

A small ovoid cavity, wider above than below, marked on its inner wall by a horizontal crest, above which is a depression (*fovea hemielliptica*), and below another smaller one (the *fovea hemispherica*). The vestibule is occupied by fluid, in which are suspended two sacs, upon which the auditory filaments are distributed. Into the vestibule open (1) the *fenestra ovalis*, (2) *apertura scalæ vestibuli*, an oval hole below and in front of the fenestra ovalis and leading into the external scala of the cochlea, and (3)

the *ostium internum aqueductus vestibuli*, a small orifice on its inner wall for a vein; this orifice is situated just below and in front of the common opening of the two vertical semicircular canals. Lastly, there are the five openings of the semicircular canals.

The **semicircular canals** are three curved tubes, one being horizontal and two vertical, arranged each at right angles to the others in the same manner as the sides of a cube. They represent, in fact, the three directions of space. The *superior vertical* has its convexity directed upwards; the *posterior vertical* has its convexity directed backwards; and the external *horizontal* has its convexity directed outwards. The inner leg of the superior vertical and the upper leg of the posterior vertical unite about two lines from their termination to form a common canal, which opens by a single aperture at the inner and back part of the roof of the vestibule. Each of the four remaining legs of the canals open into the vestibule by a separate aperture. Each canal has one extremity dilated to form an *ampulla*. They are occupied by fluid in which membranous canals float, and upon the ampullæ are distributed some of the terminal filaments of the auditory nerve.

The cochlea resembles a small snail shell, and consists of a conical central axis (*modiolus*), around which a canal is wound spirally for two and a half turns, and of a delicate lamina (*lamina spiralis ossea*) which is contained within the canal, follows its windings, and subdivides it into two. In this cochlea a special structure is found (*the organ of Corti*), whose function appears to be to determine the musical notes of sound.

Internal auditory meatus, a straight canal

seen in the interior of the base of the skull. At its bottom are seen: (1) a large opening for the facial nerve, being the commencement of the aqueductus Fallopii, which ends at the stylo-mastoid foramen; (2) a number of small perforations behind and above for auditory filaments to the vestibule; (3) a horizontal crest below these; (4) a depression with small perforations for nerves going into the modiolus of the cochlea; (5) other small perforations for nerves to the inner wall of the vestibule.

HYOID BONE.—Plate XXIII.

Synonyms : *E.* Tongue bone. *G.* Das Zungenbein.
Fr. L'hyoïde.

Situation.—This bone is situated in the throat, at the base of the tongue, and can be easily felt from outside.

Shape.—U-shaped, forming a bony arch.

Parts.—It consists of a body, two great cornua, and two small cornua.

Body is the central portion, flattened from before backwards, but placed rather obliquely, its under surface bevelled posteriorly to receive the upper edge of the thyroid; convex from side to side anteriorly, and marked by a median ridge, on each side of which are depressions for muscles.

Lesser cornu conical, springs from the outer extreme of the body, runs upwards and backwards, receives the attachment of the *stylo-hyoid ligament*, and gives origin to muscles (*middle constrictor, hyo-glossus*). This process remains separate till old age.

Great cornu projects backwards as a continuation of the body, but is developed from a different centre; it becomes smaller towards its free extremity, when it again enlarges slightly, and gives attachment to the lateral *thyrohyoid ligament.* Along its upper edge is the attachment of the *middle constrictor* and *hyoglossus muscles*, and along its lower the *thyrohyoid muscle.* This process unites with the body about middle life.

Development.—From five centres—1 for body, 1 for each cornu.

Connexions.—To thyroid cartilage, styloid process, and epiglottis.

Muscles attached, ten *or* eleven—sternohyoid, thyrohyoid, omohyoid, digastricus, stylohyoid, mylohyoid, geniohyoid, geniohyoglossus, hyoglossus, middle constrictor, and sometimes lingualis.

LARYNGEAL CARTILAGES.—Plate XXIII.

These are only mentioned here in order that their relation to the hyoid bone may be understood. In the larynx are nine cartilages, nearly all of which have a tendency to ossify in old age. The upper most or

EPIGLOTTIS,

Synonym: *G.* Der Kehldeckel,

Is a leaf-shaped fibro-cartilage placed behind the tongue, and covering the entrance to the air-passages. This is attached by its stalk to the thyroid cartilage.

THYROID CARTILAGE.

Synonym: *G.* Der Schildknorpel.

This is a shield (*θυρεός*), whose two halves or *alæ* unite in the middle line to form the pomum Adami. It has two *cornua* projecting above, and two below at its posterior limit, and its alæ are marked by an oblique line, indicating the attachment of muscles.

CRICOID CARTILAGE.

Synonym: *G.* Der Ringknorpel.

This forms a complete ring (*κρίκος*) below the thyroid. It is much deeper behind, its upper edge sloping upwards behind and supporting the arytænoid cartilages.

ARYTÆNOID CARTILAGES.

Synonym: *G.* Der Giessbecken knorpel.

Two in number, pyramidal in shape, each having three concave sides. These cartilages are of great

importance, as the vocal cords stretch between them and the back of the pomum Adami.

Other small nodules of cartilage called **cuneiform** lie in the upper vocal cords, and the **cornicula** are small nodules immediately above the arytænoids.

BONY LANDMARKS.

Under this title it is intended to draw attention to the various points of bone which can be felt or seen through the skin in the living body, and to notice their relation to one another; and the student should make himself thoroughly acquainted with these points, since they are of paramount importance in determining the nature of injuries and of certain diseases and deformities. What is normal and what is abnormal is the first difficulty which presents itself; but we have fortunately a means almost always at hand to assist us in discovering this, and the means is so simple that it is often overlooked. We have only to compare the one limb or side with the other, and we ought, on careful examination, to detect any difference in form, mobility, and power. There are cases, however, in which such comparison is rendered impossible, owing to previous deformity, or to both limbs being the seat of present injury, and in such cases a knowledge of the normal relation of bony points is an absolute necessity. The anatomist ought to see in his patient a transparent being, and should be able to picture in his mind the various structures of the body as they lie naturally grouped and connected together; and first of all in importance is the knowledge of the framework upon which the softer structures are placed. This framework can be traced by manipulation through the skin, and in the following notes the importance of each distinguishable point will be referred to.

It will be evident that the possibility of feeling many of the bony points will depend entirely upon

the amount of fat which covers the bones, and therefore in following out these remarks it will be well to select a moderately thin subject.

Skull.—The outline of the skull-cap is generally unsymmetrical: it is broadest at the parietal eminences, which in an ordinary adult skull are easily felt about four inches above the tip of the mastoid process. The parietal eminences are very liable to injury from their being most prominent, and the skull is therefore proportionally thick and dense in this situation.

The frontal eminences are readily visible, and in some persons are very prominent. The glabella or swelling over the frontal sinuses is similarly distinct in certain individuals, and usually extends a short distance into the brows: even when no bulging occurs on the surface, the sinuses usually exist in the adult, owing to the inner table being thrown back. Phrenology is at fault when it locates important mental faculties in the bulgings of air-spaces. Along the edge of the orbit the supra-orbital notch can often be felt about the junction of the inner with the middle third, and it must not be mistaken for a fracture; the two sides are often different, one possessing a notch, the other a foramen not easily felt. The eyebrow lies over the supra-ciliary ridge.

On the side of the head commencing from the external angular process of the frontal, which is easily felt and seen, we notice the temporal ridge, and below it the temporal fossa is seen filled by the temporal muscle; this is made to stand out in strong relief when the teeth are firmly clenched. When bleeding has taken place in this fossa, it is limited by the attachment of the temporal fascia along this line above and by the zygoma below. In wasting diseases when

emaciation has occurred, the temples become hollow from the absorption of the fat and tissues usually occupying this fossa, and the bones become abnormally distinct.

The orifice of the ear does not correspond accurately with that of the external auditory meatus, since the cartilaginous tube outside descends considerably on leaving the temporal bone. The orifice is ultimately overlaid in front by the tragus, a small piece of fleshy tissue which acts as a valve to the tube, and being covered with hair something like a goat's beard receives the name of tragus. In consequence of the alterations in direction in the meatus, it is necessary to pull the ear upwards and backwards in order to look into it with a speculum.

The mastoid process is distinct behind the ear, and is important as it lies immediately over the condyles of the occipital bones, which are not more than an inch and a quarter distant from the tip. It is round the line joining the two mastoid processes that movement occurs in flexion and extension of the head. The mastoid process is hollowed out by air-spaces, and suppuration may occur in these and require trephining, but if hæmorrhage has occurred within the skull it is useless to trephine over the mastoid process for the purpose of letting the blood out. Immediately below the mastoid process the tissues are dense, but the tip of the transverse process of the atlas may be felt moving with the head in its rotary movements.

The occipital protuberance is distinct behind, and it is here that the maximum thickness of the skull is reached, being often three-quarters of an inch thick in this situation. The skull varies much in thickness,

but usually this can be estimated by the size and character of the bones generally; where bones are large and the processes well marked, the skull is usually thick; in delicate subjects the bones are usually thin, and the skull has been known to be almost as thin as paper. In certain races (Negroes, Irish, &c.) and in certain diseases (osteoporosis) the bone is unusually thick. These remarks are necessary in reference to the operation of trephining or sawing through the skull, and it must be borne in mind that the inner surface is often not parallel with the outer, and consequently great care must be used to avoid going too deeply and injuring the brain.

The cerebrum occupying the skull extends as low down as a line drawn from the external angular process of the frontal to the external auditory meatus and on to the occipital protuberance. The lower limit of the cerebellum is indicated by a line drawn horizontally through, near the tip of the mastoid process.

The external angular process of the frontal is an important landmark, because the large anterior branch of the temporal artery is found pulsating about a finger's breadth behind it, and the main trunk of the same artery can also be felt, not quite a finger's breadth in front of the ear, as the vessel crosses the zygoma. These arteries have occasionally to be opened.

Face. At the inner angle of the orbit above, one can, on pressing firmly, feel the Pulley, or Tubercle, for the superior oblique, and at the outer angle above, one may distinguish the lachrymal gland when it is enlarged. At the inner angle below we may discover the lachrymal groove, which is now filled by the lachrymal sac. This sac receives the tears by means of two canals which open at the inner end of

each lid by a small point-like orifice called the punctum, and the sac transmits the fluid to the nose by the inferior meatus. Hence when tears rise in the eyes, blowing of the nose will tend to clear them away. The groove for the lachrymal sac runs in the substance of the bones in a direction downwards with a slight inclination backwards and outwards, and this must be followed in passing a probe or knife into the lachrymal sac for obstruction. It is strange that so delicate a structure as the lachrymal sac is not more liable to disease or injury; but against injury, from outside, it is protected by the facial bones; we have known, however, of one instance in which violent blowing of the nose was followed by escape of air into the cellular tissue of the orbit, and under the conjunctiva as far as the edge of the cornea, and assume that the sac must have been ruptured towards the upper end, but the return of air into the sac, from the nose, is usually prevented by a valvular fold of mucous membrane.

On the nasal bones the small notch in the lower edge is readily felt, but the nasal cartilages obscure the outline of the nares. On looking into the nose by pressing the tip upwards and backwards, it is possible to see the anterior end of the inferior turbinated bone, when the nares are large, and the healthy, red, shining mucous membrane covering it must not be mistaken for disease or for a foreign body. In the same view too it may be noticed that the septum is not usually median, but diverges to one side.

A bent probe passed along the floor of the nares, can be made to enter the Eustachian tube readily, and this has to be done when deafness is due to blocking

of this tube. It will be seen when a section of the skull is examined, that the orifice of this tube is placed from one and a half to two inches behind the anterior nares.

The incisive and canine fossæ can be felt through the skin of the face, and the latter is surgically important because it is the point usually selected for boring into the antrum, and anatomically important because the infra-orbital vessels and nerves pass through the upper part of it. The foramen lies in the same vertical line as the supra-orbital.

The malar tuberosities and superposed malar bones are readily felt and a line drawn from the lowest point of the prominence to the middle of the lower edge of the orbit, marks the malo-maxillary articulation; it is through this part that the saw is carried in removing the upper jaw, but the spheno-maxillary fissure has to be opened so that the section is made rather more perpendicularly, for the fissure lies at the lower outer angle of the orbit. The prominence of the cheek-bones gives a peculiar expression to the face, which is distinctive of certain races, but the prominence is often more apparent than real, as the hollow below the cheek-bones when deprived of its fat by wasting disease becomes exaggerated and shows up the cheek-bones into prominence.

In front of the ear is felt the tubercle of the zygoma, and by placing the hand over the condyle of the jaw the bone can be felt working in the glenoid cavity. When the mouth is open wide the condyle advances on to the eminentia articularis, and if the mouth be opened too wide, the bone slips forwards and remains dislocated. A line drawn from the condyle to the angle of the jaw indicates the posterior

margin of the ramus, and between it and the ear is the parotid gland. Incisions may be made to any depth in front of this line when there is suppuration here, but it must be remembered that the parotid duct runs across the jaw in a line drawn from the lower edge of the lobe of the ear to midway between the nose and the upper lip. About an inch and a half in front of the angle, a depression is felt in the edge of the bone, and the facial artery is here felt pulsating immediately in front of the masseter muscle.

In the mouth, the hamular process is felt on the inner side of the last upper molar tooth, and the internal pterygoid plate can be traced upwards from it; while on the outer side of the last molar the back of the antrum and the external pterygoid plate can be distinguished. The anterior border of the coronoid process can also be easily felt, and on the inner side of this is a recess where an abscess of the temporal fossa may burst or be opened. The finger should also be made familiar with the feel of the posterior nares, the tonsils, and the back of the fauces, so as to be able to distinguish when these parts are the seat of disease. In searching for enlarged submaxillary lymphatic glands, one finger should be placed in the mouth while the other manipulates outside below the jaw.

Neck. The upper cervical spinous processes cannot be felt owing to their being deeply placed under a strong fibrous ligament (the ligamentum nuchæ), which stretches from the occipital protuberance to the seventh cervical, but the last cervical spinous process is very prominent, and is called therefore the vertebra prominens.

On the sides we can feel the transverse processes, the first being distinguishable deeply under the

mastoid process. These projecting points of bone are important as guides in operations for the removal of tumours in the neck. The seventh transverse process can be felt by pressing deeply in the upper part of the supra-clavicular fossa, and occasionally a supernumerary rib projects from this, and by pressing forwards the subclavian artery may give the impression of an aneurism existing in this situation.

In front we can feel the body of the hyoid, and can distinguish the whole length of the cornua. They may be broken when a person is throttled. Below the hyoid is a gap between it and the thyroid cartilage, behind which is the apex of the epiglottis, and the outline of the alæ of the thyroid cartilages with the cornua can be readily made out. Between the thyroid and the ring of the cricoid is a small space, through which the incision is made in performing laryngotomy. Below the cricoid the trachea is felt, and about five or six of these are usually found above the level of the sternum: the upper ones of these are divided in the operation of tracheotomy.

By pressing deeply in the supra-clavicular space, under the edge of the sterno-mastoid muscle, we may distinguish the angle formed by the scalenus anticus muscle and the first rib, and upon the latter in this situation a tubercle is sometimes felt. It is here that the subclavian artery is compressed, when we wish to arrest hæmorrhage from the axillary or brachial, and it is here that the subclavian artery is to be found in the operation for tying it.

Chest. It must be remembered that the upper opening of the chest is very obliquely placed, so that the upper border of the sternum is usually on a level

with the lower edge of the body of the second dorsal vertebra.

The ribs should be traced from above downwards, and the following rules* will assist the student of anatomy.

1. The transverse projection, slight, but always to be felt, at the junction of the first with the second piece of the sternum, corresponds with the level of the cartilage of the second rib.

2. The nipple in the male is placed generally between the fourth and fifth ribs, about three-quarters of an inch external to their cartilages.

3. The direction of the fifth rib corresponds with the lower edge of the pectoralis major.

4. A line drawn horizontally from the nipple round the chest cuts the sixth intercostal space midway between the sternum and the spine. This is a useful rule in tapping the chest.

5. When the arm is raised, the first visible digitation of the serratus magnus corresponds with the sixth rib. The three lower visible digitations correspond respectively with the seventh, eighth, and ninth ribs.

6. The scapula covers the ribs from the second to the seventh inclusive.

7. The eleventh and twelfth ribs can be felt even in corpulent persons.

The coracoid process can be felt by pressing below the hollow of the clavicle, and the spine of the scapula should be traced in its whole length. The fingers may be inserted below the inferior angle of the scapula, and in examining for fracture of the bone, the angle should be held firmly by passing the thumb

* Holden, in "Barthol. Hosp. Reps.," vol. ii. p. 407.

and fingers along the axillary and vertebral borders respectively, while with the other hand the spine and upper part may be manipulated.

The apex of the heart beats between the fifth and sixth ribs, about two inches from the nipple, and one inch to its sternal side. Behind the third intercostal space, close to the left of the sternum, lie the aortic valves, and the sound due to their closure is heard distinctly along a line from this point to the junction of the second right costal cartilage with the sternum: this latter point corresponds with the commencement of the transverse part of the arch of the aorta. The junction of the third left costal cartilage with the sternum indicates the position of the pulmonary valves. The mitral valve lies behind the third intercostal space, about an inch to the left of the sternum, and the tricuspid behind the middle of the sternum, about the level of the fourth costal cartilage.

It is especially worthy of notice that the lungs project into the neck about an inch and a half above the clavicles, and that the anterior edges of the lungs of opposite sides come together behind the middle piece of the sternum, but diverge below, the left one running along the level of the fourth rib, the right along that of the sixth.

Abdomen. It is worthy of notice that the umbilicus or navel is usually opposite the third lumbar vertebra, and that the lower end of the aorta will be compressed if the thumb be pressed in deeply against it, a little on the left side of the spine. This fact is taken advantage of when amputation has to be performed at the hip-joint, or when the flow of blood has to be checked through an aneurism below.

The spine and crest of the ilium, the spine and

arch of the pubes, the tuberosity of the ischium, and the spine of the ischium, can all be readily made out by pressure. A line from the anterior superior spine of the ilium to the spine of the pubes indicates the position of Poupart's ligament, above which passes an inguinal, and below which a femoral hernia. The spine of the pubes is often a specially useful guide in distinguishing between these two forms of rupture: if the spine can be felt outside the hernia it is inguinal, if inside it is femoral. Frequently it is difficult to detect the pubic spine if the subject be fat, but if so, it is readily made out when the finger is carried from below upwards, invaginating a portion of the scrotum or labium, and by the same means it is easy to feel the margins of the exterior abdominal ring, through which an inguinal hernia may descend. The spine of the pubes is about on a level with the top of the great trochanter. The spine of the ilium lies on a higher level, and is the most distinct of the bony points in this neighbourhood. It is from here that measurement is usually taken in comparing the length of the lower limbs, and a caution must be given with reference to preserving the level of these spinous processes. There is always a tendency after injury, but more especially after disease, for the pelvis to be tilted, the spine of the affected side being raised sometimes to the extent of two inches; and consequently the apparent length of the limb will be greatly modified. Try this with a healthy person, and you will find that a tilting of the pelvis will make an apparent difference of nearly two inches, and a difference by measurement of nearly an inch. It is important to remember that a line drawn from the anterior superior spine of the ilium to the tube-

rosity of the ischium should pass immediately above the great trochanter of the femur, and if the trochanter be above this line, it must be displaced upwards.

From the rectum it is possible to feel, by means of the finger, the tuberosity of the ischium, the spine of the ischium with the sciatic ligaments, the arch of the pubes and the symphysis, and posteriorly the front surface of the coccyx and sacrum, as far as the promontory. The whole cavity of the pelvis can be thoroughly explored by this means, and the help which is afforded to diagnosis by manipulation in the rectum is especially useful.

The angle of junction between the sacrum and coccyx is often very prominent, so that after a fall on the buttocks it is quite possible to mistake this for a fracture or malformation, unless the surgeon is aware of the frequency with which this projection occurs.

Upper Extremity. At the shoulder the student should make himself thoroughly acquainted with the feel of the head of the humerus in its different movements, and examine it from the axilla, below the clavicle, and below the spine of the scapula respectively. The axillary border of the scapula should be traced upwards to the glenoid cavity, the edge of which can be distinguished while the humerus is rotated: in cases of doubtful injury about the joint, this manipulation is very important, and is the chief means by which he forms a diagnosis. Further assistance may be gained by measuring the circumference of the joint and the length of the limb, and in both cases the tip of the acromion is the fixed point from which measurement is taken.

If the finger be carried along the front surface of the clavicle, a projecting tubercle may often be distin-

guished about the junction of the middle and outer thirds, and this may be mistaken for the edge of a fracture, but an error of this kind may usually be avoided by examining the opposite clavicle. The tip of the acromion is sometimes difficult to define with sufficient clearness to insure accurate measurement, but usually there is a tubercle placed rather at the back of the acromion, which affords a very distinct landmark. Sometimes the acromion forms a separate or even a jointed epiphysis, and this condition, which is, however, very rare, may give rise to an erroneous impression of fracture: it may be avoided by examining the opposite shoulder.

The line of articulation between the clavicle and acromion should be made out, about an inch inside the tip of the shoulder. It is not very uncommon for dislocation to occur here, and when this happens, the whole shoulder drops while the clavicle projects above it. The author has twice seen this condition mistaken for dislocation of the humerus. But such an error ought not to be made, for when the head of the humerus is dislocated, the clavicle and acromion are continuous, and the shoulder is hollowed out below the acromion—not filled out as it should be by the head and tuberosities of the humerus.

By deep pressure in the axilla we may distinguish the bicipital groove, which looks directly forward when the elbow is brought to the side: it may be mistaken for a fracture. We may also feel the ribs whose rounded surfaces may, as the finger slips over them, give the idea of hard glands or abnormalities, unless they be compared with a healthy axilla.

The surgical neck of the humerus is generally felt without trouble, and the musculo-spinal groove on

the outer side of the shaft. By pressing directly outwards against the humerus in the upper third, or directly backwards, at the bend of the elbow, the brachial artery is compressed, and bleeding prevented from the vessel below.

At the elbow notice how much more the inner condyle projects than the outer, and how it is possible for it to be chipped off without implicating the joint, an accident which is hardly possible with the outer. Above the inner condyle may often be felt a tubercle or exostosis homologous with a permanent process (the supra-condyloid) in many animals. Behind the inner condyle the ulnar nerve is felt as the "funny bone," and it is important to avoid this in operations about the elbow. Sometimes there is a small tubercle felt about half an inch above the external condyle, and it may be noticed that this condyle is situated rather lower down than the inner.

The olecranon is distinctly traceable and is rather nearer to the inner than to the outer condyle, and on its outer side, just below the external condyle, is a dimple, in which the head of the radius can be felt rotating. To feel this distinctly the thumb should be pressed inside the mass of muscles on the outer side of the elbow and the finger in the dimple just referred to, and the arm flexed; the hand is then made to rotate, and the head of the radius should be felt to rotate also: it is by such manipulation that a fracture in the shaft or neck of the bone or a displacement of the head of the radius can be distinguished. The tip of the olecranon should not in any position of the arm rise higher than the line between the condyles. In people who use their elbows much to lean upon, a bursa is formed over the back of the olecranon.

There is a lymphatic gland above the external condyle which often becomes inflamed when the hand is poisoned.

In the forearm you may trace the inner edge of the ulna in its whole length, and the styloid process must be noticed as extending not quite so low as that of the radius, but it indicates the level of the wrist-joint.

The lower half of the radius is traced much more easily than the upper, and it must be remembered that fracture most commonly occurs close to the lower end, and may be readily overlooked or mistaken for a dislocation at the wrist-joint. It must also be borne in mind, that a horizontal ridge often naturally occurs close to the lower end; but this would in most cases be found also in the opposite radius, which should be compared with it. At the back of the radius the most prominent longitudinal ridge lies on the outer edge of the groove for the extensor of the second phalanx of the thumb.

At the wrist we can feel the tubercle of the scaphoid just below the styloid process of the radius in the palm or surface, and below this the bony prominence of the ridge of the trapezium, while on the ulnar side of the same surface of the wrist we feel the pisiform and unciform bones; between these prominences the strong anterior annular ligament is stretched.

In the palm of the hand, each metacarpal bone should be separately traced, and the mobility of those belonging to the thumb, ring, and little finger especially noticed. Towards the fingers the metacarpo-phalangeal joints can be felt to correspond, when the fingers are flexed, with a transverse furrow (or more commonly with parts of two furrows), about

an inch from the edge of the webs; this must be remembered in amputating at this joint.

On the thumb we can feel the sesamoid bones on the base of the so-called first phalanx, and on the wrist side of these the joint is situated.

The position of the phalangeal joints must be carefully sought for. They will be found to correspond with the largest transverse furrows on the palmar surface of the fingers, and with the furthest furrows on the dorsum, so that in amputating a phalanx from the dorsum, the knife must be made to cut in apparently beyond the head of the bone and not behind it.

Lower Extremity. There are two furrows of importance in the groin; one which has been already referred to extends between the anterior superior spine of the ilium and the spine of the pubes and corresponds with Poupart's ligament; the other stretches from the angle between the scrotum and the thigh to the top of the great trochanter and marks the position of the hip-joint. The latter furrow is obliterated when the joint is distended. Over the great trochanter is a well-marked depression under which is the fascia of the glutæus maximus muscle covering a large bursa.

The femur can be best traced on the outer side, but it is generally covered thickly by muscles. The condyles, however, are subcutaneous; on the inner, search should be made for a tubercle which is not very uncommon, and which runs upwards in the tendon of the adductor magnus. It is here that an exostosis may be found which may interfere with the riding capabilities of a man, and therefore unfit him for the cavalry.

The mobility of the patella should be noticed, and it should be remembered that the capsule of the knee-joint extends to about two fingers' breadth above this bone. When the knee is extended nearly all the patella is above the condyles of the femur, and it can be made out that in the different positions of the knee the patella is differently related to the femur, but nearly always more in contact with the outer than with the inner condyle. (*See* page 129.) Dislocation outwards is therefore most common. Over the patella is a large bursa which when enlarged constitutes "housemaid's knee."

The head of the tibia can be readily traced, and the shallow groove between it and the condyles can be felt, indicating the position of the knee-joint. The tubercle of the tibia is prominent in front and the ligamentum patella is felt passing into it. A bursa is situated under the ligament above the tubercle, and is sometimes inflamed; it is important to know that it does not communicate with the joint. Bony growths may occur on the tibia at the tubercle or on the sides of the head and are often symmetrical.

The head of the fibula is readily distinguished, about an inch below the top of the tibia, and therefore altogether below the knee-joint. The styloid process projects upwards from the back of the head, and the external lateral ligament can be felt running upwards from it.

The whole length of the fibula should be traced carefully. It is under the pad of peronei muscles in the upper half or more, but becomes subcutaneous towards the lower end, and if one hand be firmly fixed upon any portion by grasping the limb, and the other hand be made to press the bone against the

tibia, the elasticity of the fibula can be detected on remitting the pressure; but when the shaft is broken the elasticity of the bone is lost. This is a very useful aid to diagnosis in cases of suspected fracture. It must be noticed that the fibula is placed perpendicularly in a line with the outer condyle of the femur, and this fact, together with what can be seen in the structure of the bone, points to its carrying some of the vertical pressure of the weight of the body. The most frequent seat of fracture is in the lower fourth.

The position of the malleoli should be carefully noted. The external descends lower than the internal and is placed further backwards, so that in performing Syme's amputation of the foot, the incisions should be carried from the front of the external to the tip of the internal malleolus.

In placing a limb upon a splint it is well to bear in mind that normally the inner edge of the patella, the inner ankle, and the inner side of the great toe are in a line.

The position of the ankle-joint is indicated by a line drawn about a finger's breadth above that joining the two malleoli.

In the foot we notice the tuberosity of the os calcis, and can feel the strong tendo-Achillis running into it above. On the outer side of the os calcis we feel (*a*) the outer tuberosity, (*b*) the peroneal tubercle below and slightly in front of the external malleolus, (*c*) the depression of the cuboid with the ridge towards the plantar surface, distinguished only by deep pressure, and lastly (*d*) the prominent tuberosity of the fifth metatarsal bone. On the inner side we can feel besides (*a*) the tuberosity of the os calcis and the

internal malleolus, (*b*) the sustentaculum-tali below the latter, (*c*) the tubercle of the scaphoid, which is always easily distinguishable, and behind which is the calcaneo-scaphoid ligament which supports the head of the astragalus, then (*d*) the tuberosity of the internal cuneiform bone, and (*e*) the base of the first metatarsal. Between these prominences the depressions for the joints are traceable.

In performing Chopart's amputation place the thumb upon the tubercle of the scaphoid and the finger upon the gap behind the tuberosity of the fifth metatarsal bone, and the knife can be carried directly through the joints in front of the astragalus and os calcis, and the front of the foot removed; the prominent edge of the front of the os calcis should be made out, as it assists the operator to bear this in mind.

Immediately in front of the ankle-joint the neck and head of the astragalus should be felt, but in many cases of flat-foot, a considerable hollow exists here owing to the head of the astragalus being carried to the inner side of the foot, the calcaneo-scaphoid ligament being weakened. The same cavity exists when the astragalus is dislocated from injury.

The same rules apply to the joints of the metatarsus and phalanges as have already been mentioned in describing the hand.

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